Final

Total Maximum Daily Loads

for

Dissolved Oxygen and Nutrients

in

McKay Bay (WBID 1584B), Palm River (1536E), and Ybor City Drain (1584A)

March 2013

In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et. seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S. Environmental Protection Agency is hereby establishing the Total Maximum Daily Load (TMDL) for dissolved oxygen & nutrients in the Tampa Bay Basin (WBIDs 1584B, 1536E, 1584A). Subsequent actions must be consistent with this TMDL.

________________/s/__________________________ ___3/25/2013___

James D. Giattina, Director Date

Water Protection Division

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LIST OF ABBREVIATIONS

BMAP	Basin Management Action Plan
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CO_2	Carbon Dioxide
DO	Dissolved Oxygen
EMC	Event Mean Concentration
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FLUCCS	Florida Land Use Cover Classification System
FS	Florida Statutes
GIS	Geographic Information System
HSPF	Hydrologic Simulation Program Fortan
HUC	Hydrologic Unit Code
IWR	Impaired Surface Waters Rule
KM^2	Square Kilometers
L	Liters
L/FT^3	Liters per Cubic Foot
LA	Load Allocation
LB/YR	Pounds per year
LSPC	Loading Simulation Program C++
MDAS	Mining Data Analysis System
MFL	Minimum Flows and Levels
MGD	Million Gallons per Day
MG/L	Milligram per liter
ML	Milliliters
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
NASS	National Agriculture Statistics Service
NH_4	Ammonia Nitrogen
NHD	National Hydrography Data
NO_2	Nitrite
NO_3	Nitrate

NPDES	National Pollutant Discharge Elimination System
OBS	Observations
OSTD	Onsite Treatment and Disposal System
SWFWMD	Southwest Florida Water Management District
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WASP	Water Quality Analysis Simulation Program
WBID	Water Body Identification
WLA	Waste Load Allocation
WQS	Water Quality Standards
WMD	Water Management District
WWTP	Waste Water Treatment Plant

SUMMARY SHEET
Total Maximum Daily Load (TMDL)

1998 303(d) Listed Waterbodies for TMDLs addressed in this report:

WBID	Segment Name	Class and Waterbody Type	Major River Basin	HUC	County	State
1584B	McKay Bay	Class III Marine	Tampa Bay Basin	03100206	Hillsborough	Florida
1536E	Palm River Tidal	Class III Marine	Tampa Bay Basin	03100206	Hillsborough	Florida
1584A	Ybor City Drain	Class III Freshwater	Tampa Bay Basin	03100206	Hillsborough	Florida

TMDL Endpoints/Targets:

Dissolved Oxygen and Chlorophyll a

TMDL Technical Approach:

The Total Maximum Daily Load (TMDL) allocations were determined by analyzing the effects of nutrient loads on the dissolved oxygen (DO) in the respective waterbodies against defined endpoints. This was based upon assessment of the available recent data for Chl a against the identified target. From this assessment it was determined that the waterbody was meeting its target for Chl a, therefore DO became the default parameter for assessment of load reductions. Watershed loads developed as part of the Tampa Bay Nitrogen Management Consortium Reasonable Assurance (RA) Plan were utilized as loads to a 3-dimensional hydrodynamic and water quality model system that included portions of Hillsborough Bay, East Bay, McKay Bay, and the tidal portion of the Palm River to S-160. The loads were developed for, and the hydrodynamic and water quality models calibrated to, the period from 2003 to 2007. This period also was utilized as the baseline or existing condition for TMDL compliance. The TMDL evaluated the impacts associated with reductions in the loads to the receiving waters on DO. The low DO within the receiving waters is driven primarily by the sediment oxygen demand (SOD). Therefore, ultimately, the TMDL represents changes in loadings necessary to reduce the SOD in the system a sufficient amount to allow the DO endpoint to be met.

TMDL Waste Load and Load Allocation

TMDL Load Allocations for Total Nitrogen

WBID		WLA				
No.	Name	MS4s (lbs/year)	Point Sources (lbs/year)	LA	MOS	TMDL (lbs/year)
1584B	McKay Bay	66,683	0	N/A	Implicit	66,683
1536E	Palm River Tidal	58,210	0	N/A	Implicit	58,210
1584A	Ybor City Drain	8,473	0	N/A	Implicit	8,473

TMDL Load Allocations for Total Phosphorus

WBID		WLA				
No.	Name	MS4s (lb/year)	Point Sources (lb/year)	LA	MOS	TMDL (lbs/year)
1584B	McKay Bay	13,360	0	N/A	Implicit	13,360
1536E	Palm River Tidal	11,471	0	N/A	Implicit	11,471
1584A	Ybor City Drain	1,889	0	N/A	Implicit	1,889

Endangered Species Present (Yes or Blank): Yes

USEPA Lead TMDL (USEPA or Blank): No

TMDL Considers Point Source, Nonpoint Source, or Both: Both

Major NPDES discharges to surface waters addressed in USEPA TMDL:

Name	Permit No.	WBID	Receiving Water	Type	RA Load Allocation
Hillsborough County Falkenburg WTP	FL0040614	1536A	Palm River	Domestic	15.2 tons TN/year
Trademark Nitrogen	FL0000647	1536A	Palm River	Industrial	0.04 tons TN/year *
Tampa Bay Regional WTP	FL0187691	1536A	Palm River	Domestic	1.5 tons TN/year
Kinder Morgan Hartford Terminal	FL0001643	1605D	East Bay	Industrial	75 tons TN/year **
Kinder Morgan NH3 Facility	FL0000264	1637	East Bay	Industrial	
Kinder Morgan Port Sutton	FL0122904	1637	East Bay	Industrial	
Tampa Electric Co (TECO) Bayside	FL0000809	1605D	East Bay	Industrial	0.76 tons TN/year *
Yara North America	FL0038652	1637	East Bay	Industrial	0.34 tons TN/year *
Eastern Terminal	--	1615	East Bay	Fertilizer Handling	5.6 tons TN/year
CF Industries	--	1584A	East Bay	Fertilizer Handling	3.4 tons TN/year
CSX	--	1615	East Bay	Fertilizer Handling	5.6 tons TN/year

*This tonnage is the portion of the federally recognized TMDL load assigned to this facility. The actual allocations for Trademark Nitrogen, Yara North America, and TECO Bayside are 0.004%, 0.03% and 0.07%, respectively, of the hydrologically affected load to Hillsborough Bay.
**Interim through 2012.

1. Introduction

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology-based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources [U.S. Environmental Protection Agency (USEPA), 1991].

The Florida Department of Environmental Protection (FDEP) developed a statewide, watershed-based approach to water resource management. Under the watershed management approach, water resources are managed on the basis of natural boundaries, such as river basins, rather than political boundaries. The watershed management approach is the framework FDEP uses for implementing TMDLs. The state's 52 basins are divided into five groups, and water quality is assessed in each group on a rotating five-year cycle. FDEP also established five water management districts (WMDs) responsible for managing ground and surface water supplies in the counties encompassing the districts. McKay Bay, the Palm River tidal section, and Ybor City Drain are located in the Hillsborough River Basin and are part of the FDEP Basin Group 1.

For the purpose of planning and management, the WMDs divided the district into planning units defined as either an individual primary tributary basin or a group of adjacent primary tributary basins with similar characteristics. McKay Bay, Palm River, and Ybor City Drain are located within the Coastal Hillsborough Bay Basin Planning Unit. These planning units contain smaller, hydrological based units called drainage basins, which FDEP further divided into "water body segments." Unique numbers or waterbody identification (WBID) numbers are assigned to each water segment. This TMDL report addresses WBIDs 1584B (McKay Bay), 1536E (Palm River Tidal), and 1584A (Ybor City Drain).

2. Problem Definition

To determine the status of surface water quality in Florida, three categories of data – chemistry data, biological data, and fish consumption advisories – are evaluated to determine potential impairments. The level of impairment is defined in the Identification of Impaired Surface Waters Rule (IWR), Section 62-303 of the Florida Administrative Code (FAC). The IWR is FDEP's methodology for determining whether waters should be included on the state's planning list or verified list. Potential impairments are determined by assessing whether a waterbody meets the criteria for inclusion on the planning list. Once a waterbody is on the planning list, additional data and information are collected and examined to determine if the water should be included on the verified list.

The TMDLs addressed in this document are being established pursuant to commitments made by the USEPA in the 1998 Consent Decree in the Florida TMDL lawsuit (Florida Wildlife Federation, et al. v. Carol Browner, et al., Civil Action No. 4: 98CV356-WS, 1998). That Consent Decree established a schedule for TMDL development for waters listed on Florida's USEPA-approved 1998 Section 303(d) list. Based upon the consent decree, USEPA is responsible for developing TMDLs for WBIDs 1584B (McKay Bay), 1536E (Palm River Tidal), and 1584A (Ybor City Drain). The geographic locations of these WBIDs are shown in Figure 1. The parameters addressed in this TMDL are nutrients [chlorophyll a (Chl a)] and dissolved oxygen (DO).

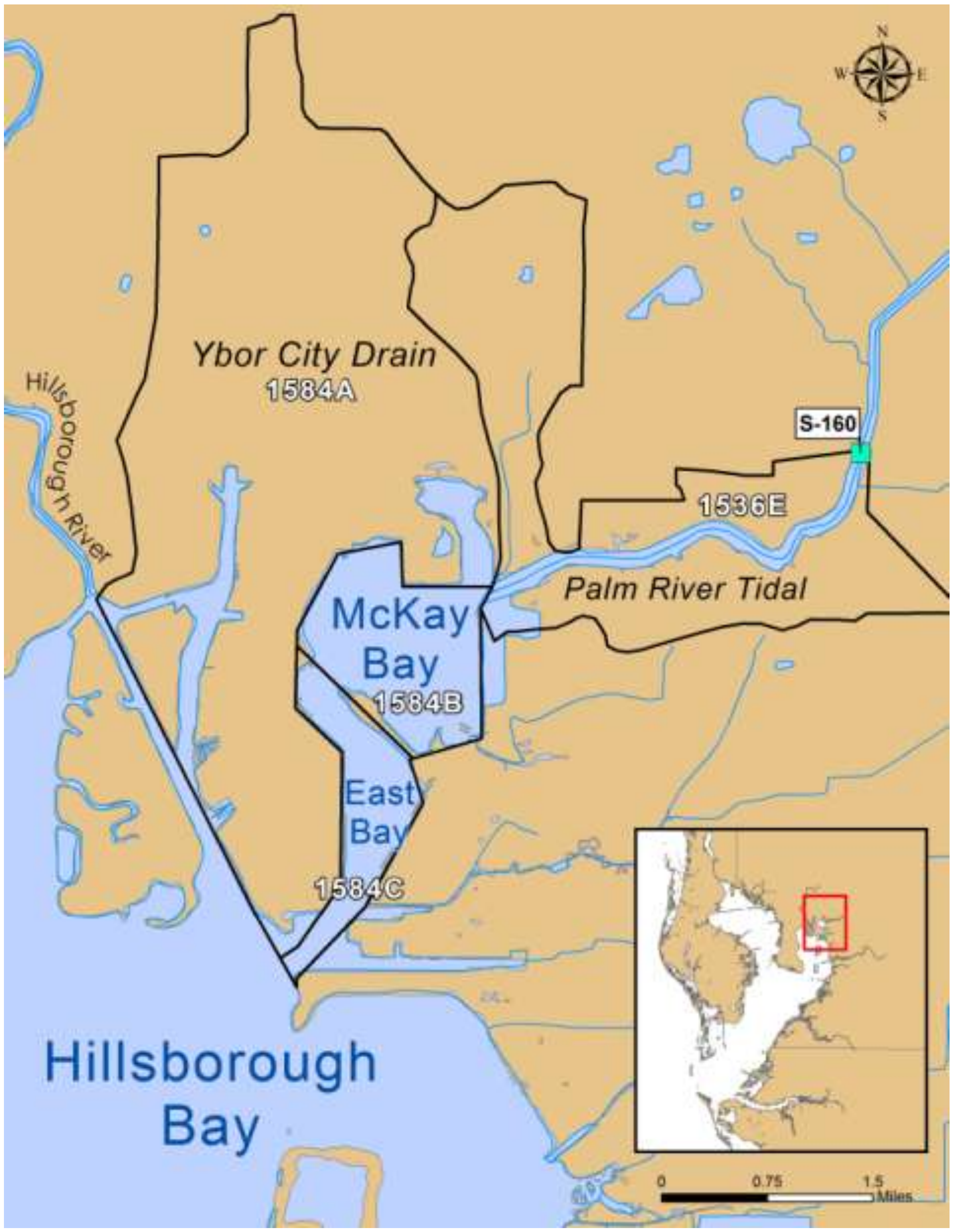


Figure 1 - Location Map for WBIDs 1584B (McKay Bay), 1536E (Palm River Tidal), and 1584A (Ybor City Drain)

Based upon assessments made for the development of the 1998 303(d) list, McKay Bay (1584B) and Palm River Tidal (1536E) were identified as impaired for nutrients and DO. Ybor City Drain was listed as impaired for nutrients and biochemical oxygen demand (BOD).

Subsequent to the development of the 1998 303(d) list, the State of Florida has gone through numerous assessment cycles for these water bodies, including a Cycle 1 assessment in 2002 and a Cycle 2 assessment in 2009. In the 2002 Cycle 1 assessment, both McKay Bay (1584B) and Palm River Tidal (1536E) were verified as impaired for nutrients and DO. In that same assessment, Ybor City Drain (1584A) was moved to category 3a for all parameters based on the fact that "the watercourse is predominantly an underground stormwater drainage system." In the 2009 Cycle 2 assessment, Ybor City Drain was moved back onto the verified list for BOD and COD based upon EPA's denial of delisting of this waterbody submitted in Cycle 1.

Numerous draft TMDLs for these waterbodies have been developed. In 2004, FDEP developed a draft TMDL for nutrients and DO for McKay Bay (1584B). In 2009, FDEP developed a draft TMDL for DO and nutrients for McKay Bay, Palm River, and Six Mile Creek that EPA proposed.

3. Watershed/Waterbody Descriptions

East Bay, McKay Bay, and the tidal portion of the Palm River are connected in series starting at their entrance in the northern end of Hillsborough Bay (Figure 1). These estuarine waterbodies make up the downstream end of the Tampa Bypass Canal (TBC) prior to its discharge into Hillsborough Bay. A flow control structure (S-160) separates the tidal/marine portion of the Palm River from the freshwater portions, which extend upstream of S-160.

The TBC is a manmade/hydrologically controlled drainage system that was built between 1967 and 1983 as part of flood control projects by the U.S. Army Corps of Engineers (USACE). Prior to 1970, Six Mile Creek and the Palm River drained approximately 40 square miles above McKay Bay. As part of the flood control project, Palm River and Six Mile Creek were deepened to 20 feet, widened to 500 to 600 feet, and armored along the full length. Additionally, a connection and structures were put into place to allow diversion of the Hillsborough River into the TBC (see Figure 2). The purpose was to provide flood flow diversion of the Hillsborough River to reduce flooding within downtown Tampa and Temple Terrace.

The hydrology of the system is highly controlled through the operation of a series of structures located along the TBC. Figure 2 shows the locations and numbers of the structures. S-160, S-161, S-162, and S-159 are flow control structures consisting of multiple vertical lift gates seated on the crest of a weir. These are controlled jointly by Tampa Bay Water (TBW) and the Southwest Florida Water Management District (SWFWMD). Structures S-160, S-162, and S-159 divide the TBC into three distinct hydrologic units, termed the lower, middle and upper pools. The levels within each pool, maintained to reduce the impacts to the local ground water hydrology, were identified based upon the depth of the canal excavation impinging upon the aquifer.

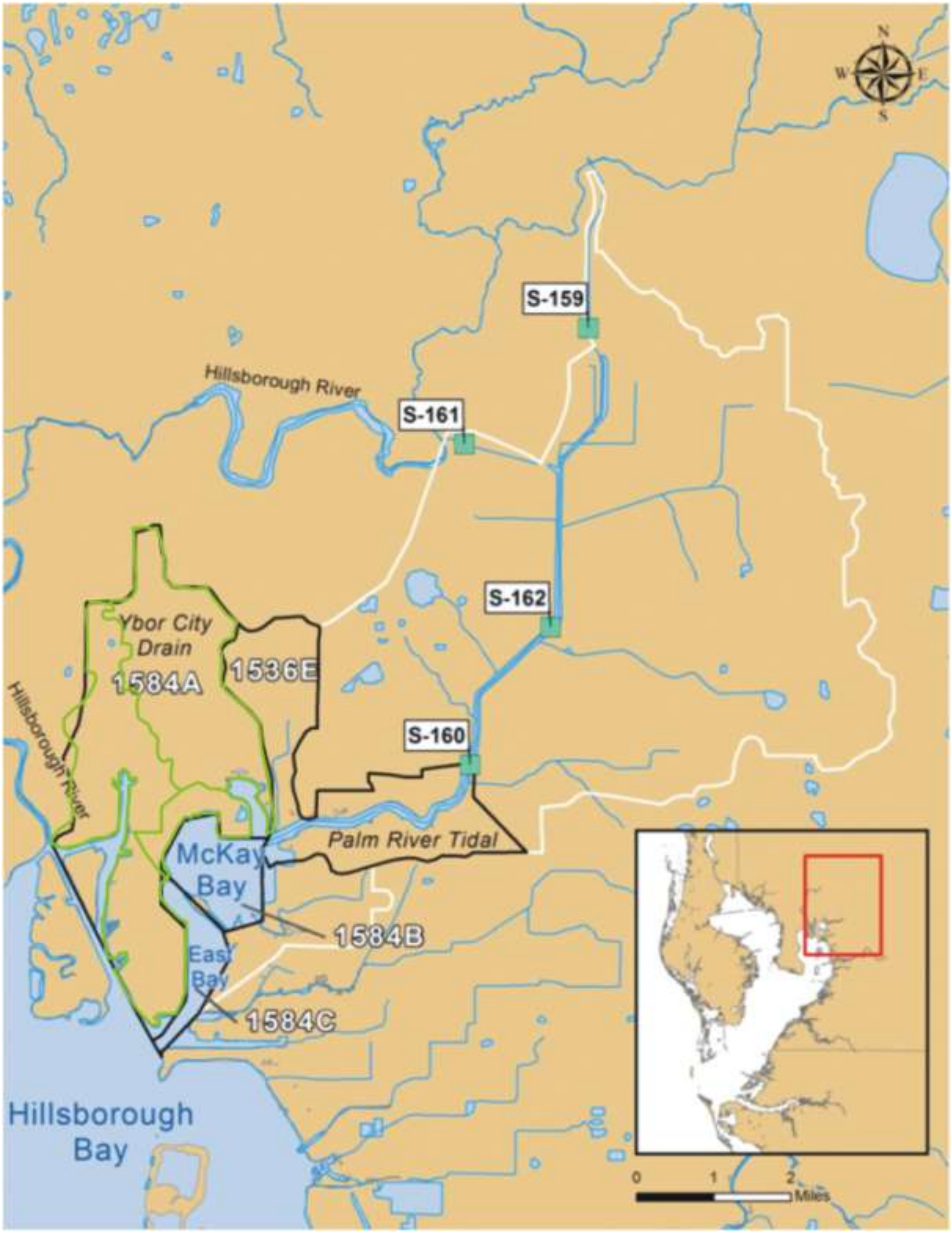


Figure 2 – Watershed Map with TBC Structures and WBIDs

Figure 3 presents a schematic representation of how the TBC system operates. Structure S-161 is the control structure that regulates flow diversion from the Hillsborough River, but there is also the capability to pull flows out of the middle pool back into the Hillsborough Reservoir, as shown on the schematic. TBW maintains two water supply intakes, one within the lower pool and one within the middle pool. These account for withdrawals from these pools based upon pre-defined operational guidelines and water supply needs.

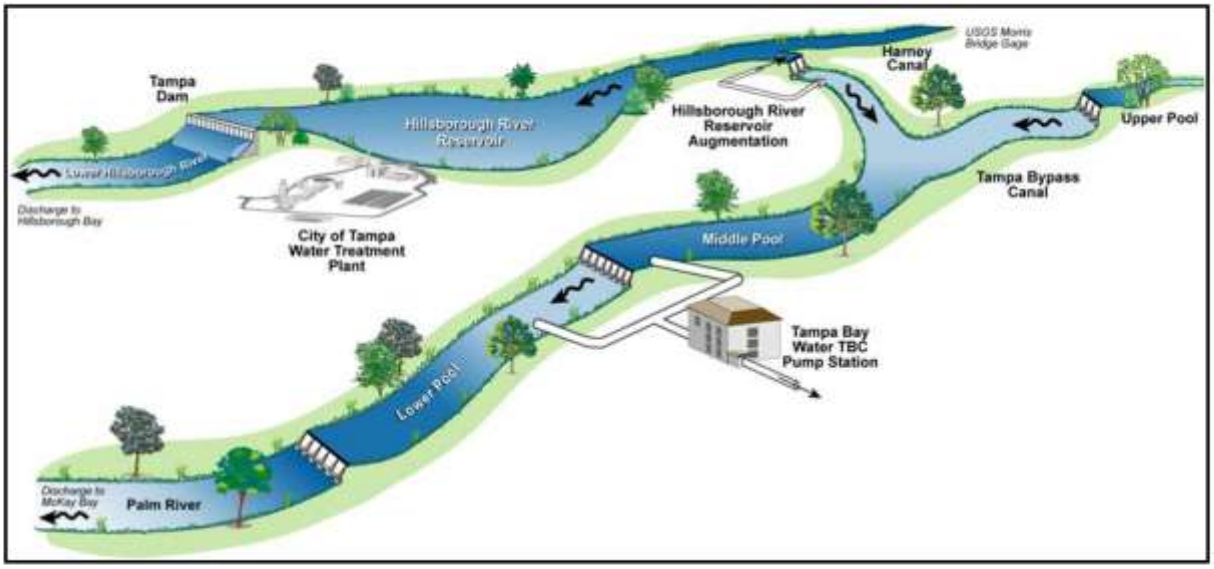


Figure 3 – Schematic Representation of Flow Diversions in Tampa Bypass Canal

Figure 2 provides a map showing the full extents of the watershed draining to East Bay, McKay Bay, and Palm River Tidal (outlined in white). The total watershed area identified in the figure is 31,718 acres, with 19,956 acres discharging into the TBC above structure S-160, and 11,763 acres that drain directly to East Bay, McKay Bay, and Palm River Tidal. The overall drainage area to the system increases dramatically when flow is diverted from the Hillsborough River into the TBC.

Figures 1 and 2 show the extents of the Ybor City Drain WBID. The Ybor City Drain (also known as the 29th Street Drainage Canal) is composed almost entirely of an underground drainage system, with the only extents of the waterbody above ground being the last 1500 feet, which discharge to the upper lobe of McKay Bay. Figure 4 presents the Ybor City Drain WBID overlain on an aerial image. A magnified view is presented in the bottom right corner of the image showing the bottom end of the Ybor City Drain and the extents of the channel above ground.

Figure 5 presents the land use distribution for the full watershed. Table 1 presents the land use breakdown above and below S-160 while Table 2 presents a breakdown by the three primary WBIDs. The land uses in the watershed below S-160 discharging directly to the Palm River and McKay Bay are almost entirely urban and industrial. Above S-160, while also primarily urban, there are areas of rangeland, forest and barren land.

Figure 4 – Ybor City Drain WBID (1584A) Overlain onto an Aerial Image (above ground portion shown in zoomed in view)

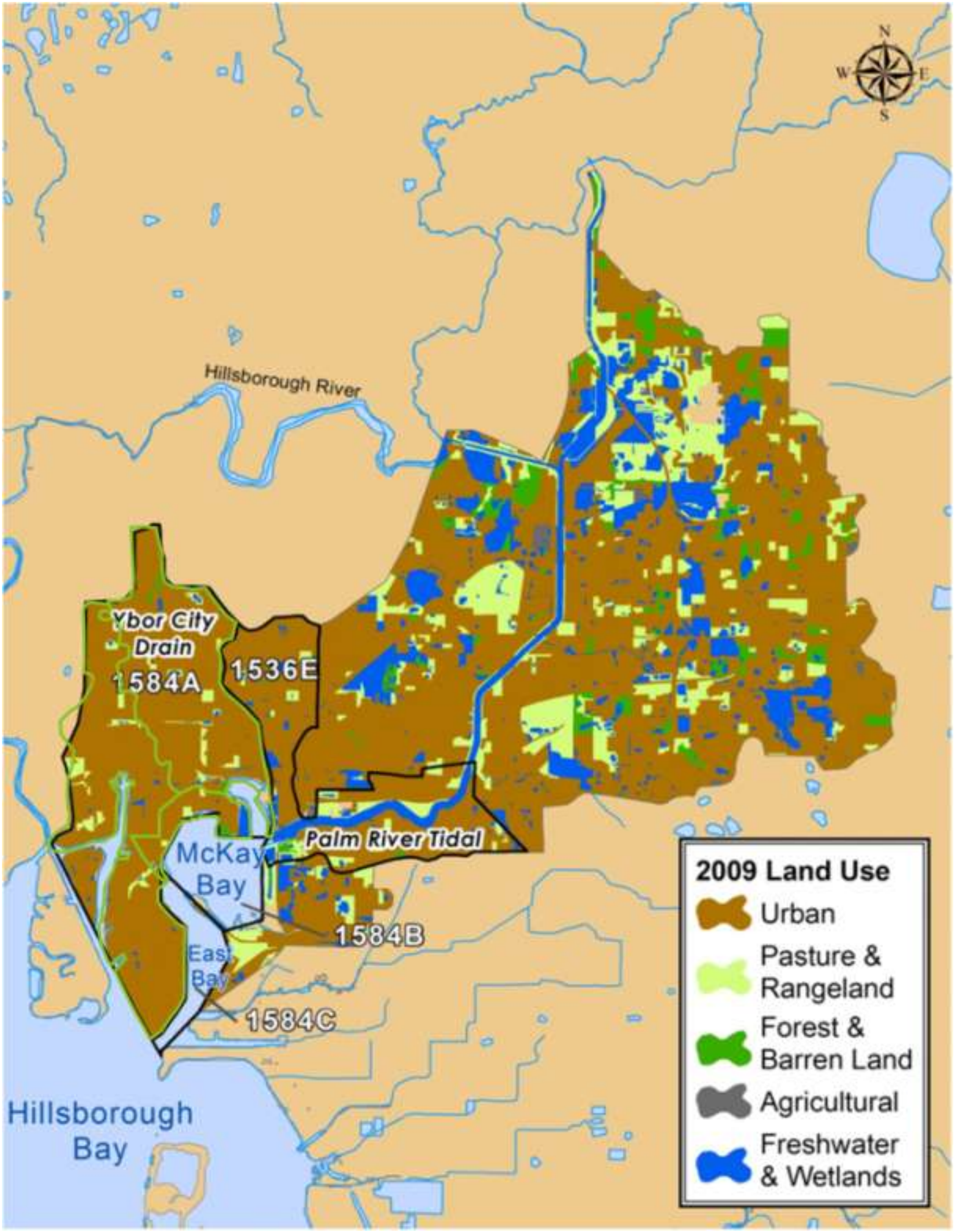


Figure 5 – Land Use Distribution in TBC and McKay Bay Watershed

Table 1 – Land Use Distribution for Watershed Area Above S-160 and Below S-160.

Land Use	Acres	Percent
Land Use Distribution for Watershed Above S-160		
Agricultural	150	1%
Forest & Barren Land	982	5%
Freshwater Wetlands	3,078	15%
Pasture & Rangeland	3,097	16%
Urban	12,649	63%
Total	19,956	100%
Land Use Distribution for Watershed Below S-160		
Agricultural	4	0%
Forest & Barren Land	101	1%
Freshwater Wetlands	853	7%
Pasture & Rangeland	834	7%
Urban	9,971	85%
Total	11,763	100%
Land Use Distribution for Full Watershed		
Agricultural	153	0%
Forest & Barren Land	1,083	3%
Freshwater Wetlands	3,931	12%
Pasture & Rangeland	3,931	12%
Urban	22,619	71%
Total	31,718	100%

Table 2 – Land Use Distribution in McKay Bay (WBID 1584B), Palm River Tidal (WBID 1536E), and Ybor City Drain (WBID 1584A) (from 2009 SWFWMD land use).

Land Use	Acres	Percent
Land Use Distribution for McKay Bay (WBID 1584B) (not including open estuary)		
Freshwater Wetlands	<1	2%
Pasture & Rangeland	4	27%
Urban	11	71%
Total	16	100%
Land Use Distribution for Palm River Tidal (WBID 1536E)		
Forest & Barren Land	28	1%
Freshwater Wetlands	374	13%
Pasture & Rangeland	281	9%
Urban	2,318	77%
Total	3,001	100%

Land Use	Acres	Percent
Land Use Distribution for Ybor City Drain (WBID 1584A)		
Forest & Barren Land	36	1%
Freshwater Wetlands	114	2%
Pasture & Rangeland	247	4%
Urban	5,305	93%
Total	5,702	100%

4. Water Quality Standards/TMDL Targets

The waters in McKay Bay (1584B) and Palm River Tidal (1536E) are Class III marine waters with a designated use of Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife. Ybor City Drain (1584A) is a Class III freshwater with a designated use of Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife. Designated use classifications are described in Florida's water quality standards in Section 62-302.400, FAC. Water quality criteria for protection of all classes of waters are established in Section 62-302.530, FAC. Individual criteria should be considered in conjunction with other provisions in water quality standards, including Section 62-302.500 FAC, which establishes minimum criteria that apply to all waters unless alternative criteria are specified (Section 62-302.530, FAC). The specific criteria addressed in this TMDL document are provided in the following sections.

4.1. Nutrient Criteria

The narrative nutrient criterion for Class III waters is as follows:

> The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man-induced nutrient enrichment (total nitrogen and total phosphorus) shall be considered degradation in relation to the provisions of Section 62-302.300, 62-302.700, and 62-4.242, FAC. [FAC 62-302.530(47)(a)]
>
> In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. [FAC 62-302.530(47)(b)]

Because the state of Florida does not have numeric criteria for nutrients; chlorophyll, DO, and other indicators (seagrasses, light attenuation, etc.) may be used to indicate whether nutrients are present in excessive amounts.

4.2. Dissolved Oxygen Criteria

Numeric criteria for DO are expressed in terms of minimum and daily average concentrations. The water quality criteria for the protection of Class III fresh/marine waters are as follows:

> **FRESH:** Shall not be less than 5.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained. [FAC 62-302.530 (30)]
>
> **MARINE:** Shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained. [FAC 62-302.530 (30)]

4.3. Natural Conditions

In addition to the standards for nutrients and DO described in Sections 4.1 and 4.2, Florida's standards include provisions that address waterbodies that do not meet the standards due to natural background conditions.

Florida's water quality standards provide a definition of natural background:

> "Natural Background" shall mean the condition of waters in the absence of man-induced alterations based on the best scientific information available to the Department. The establishment of natural background for an altered waterbody may be based upon a similar unaltered waterbody or on historical pre-alteration data. [FAC 62-302.200(16)]

Florida's water quality standards also provide that:

> Pollution which causes or contributes to new violations of water quality standards or to continuation of existing violations is harmful to the waters of this State and shall not be allowed. Waters having water quality below the criteria established for them shall be protected and enhanced. However, the Department shall not strive to abate natural conditions. [FAC 62-302.300(15)]

4.4. TMDL Targets

Specific water quality criteria targets and the approach for determination of compliance must be developed to perform a TMDL assessment. For the McKay Bay and Palm River TMDLs, a technical memorandum was prepared that outlined methodologies and results for numeric interpretation of the narrative nutrient criteria and the assessment of DO criteria and compliance. This document is included as Appendix A. It outlines all analyses, assumptions, and results for the determination of the TMDL endpoints. The following summarizes the findings.

In McKay Bay (1584B) a Chl a target of 19.4 micrograms per liter (µg/L) as an annual average was determined based on restoration of seagrass habitat to levels found in the 1950s. For nutrients, in order to be protective of downstream uses, a total nitrogen (TN) target of 1.01 milligrams per liter (mg/L) as an annual geometric mean was established. It is important to note that numerous previous studies identified that the waters in Tampa Bay, including McKay Bay, are highly nitrogen limited. Therefore, nutrient targets reflect that condition and focus primarily on TN. The TP target was identified based upon the 0.45 mg/L target identified to Hillsborough Bay under the NNC development.

In the Palm River, based upon the present physical conditions and the unrealistic goal of re-establishing seagrasses (based on dredged depths to 7 meters), a TN target was identified to be protective of downstream waters.

For both McKay Bay and Palm River, the DO targets are set to the present state of Florida criteria as outlined above. These are a minimum daily average of 5.0 mg/L with no values below 4.0 mg/L.

4.5. Assessment of Ybor City Drain

Figure 4 provides an aerial view showing the extents of the above-ground portions of the Ybor City Drain. As shown, only 1500 feet of the drain is actually above ground, and the limited area is a dredged canal that discharges to the northern lobe of McKay Bay. Therefore, it was determined that assessment of the TMDL loads needed to meet designated uses within this waterbody would not be practical. The TMDL will assess the loads from Ybor City Drain as they relate to achievement of the designated uses within McKay Bay and downstream and the TMDL for Ybor City Drain set accordingly.

5. Water Quality Assessment

WBIDs 1584B (McKay Bay) and 1536E (Palm River Tidal) were listed as not attaining their designated uses on Florida’s 1998 303(d) list for nutrients and DO. To evaluate the level of impairment, an assessment of available data was conducted. The historic and current ambient monitoring data for these WBIDs come from two sources: the Hillsborough County Environmental Protection Commission (EPC) monitoring program, and the TBW Hydrobiological Monitoring Program (HBMP). For the analyses herein, the data were downloaded directly from EPC and HBMP. These monitoring programs upload their data to the FDEP IWR database.

Figure 6 provides the station locations for the EPC monitoring program within Palm River Tidal (EPC 109 and 110) and McKay Bay (EPC 58). These stations have been monitored monthly since the 1970s and 1980s so they provide a good long-term record of the water quality conditions within the two water bodies. For the Palm River Tidal WBID, station 109 is more representative of the mixed conditions throughout the WBID since station 110 will most likely be reflective of the quality of water passing over S-160.

The HBMP data represent monthly water quality sampling performed by Tampa Bay Water (based on a probabilistic random sampling design) in McKay Bay and Palm River Tidal as stipulated in its water use permit. The green dots on Figure 6 present the locations where samples have been taken during the period of measurement (2000 to the present). These data tend to provide a more direct assessment of the WBID-wide conditions rather than the long-term trend of conditions at a single location.

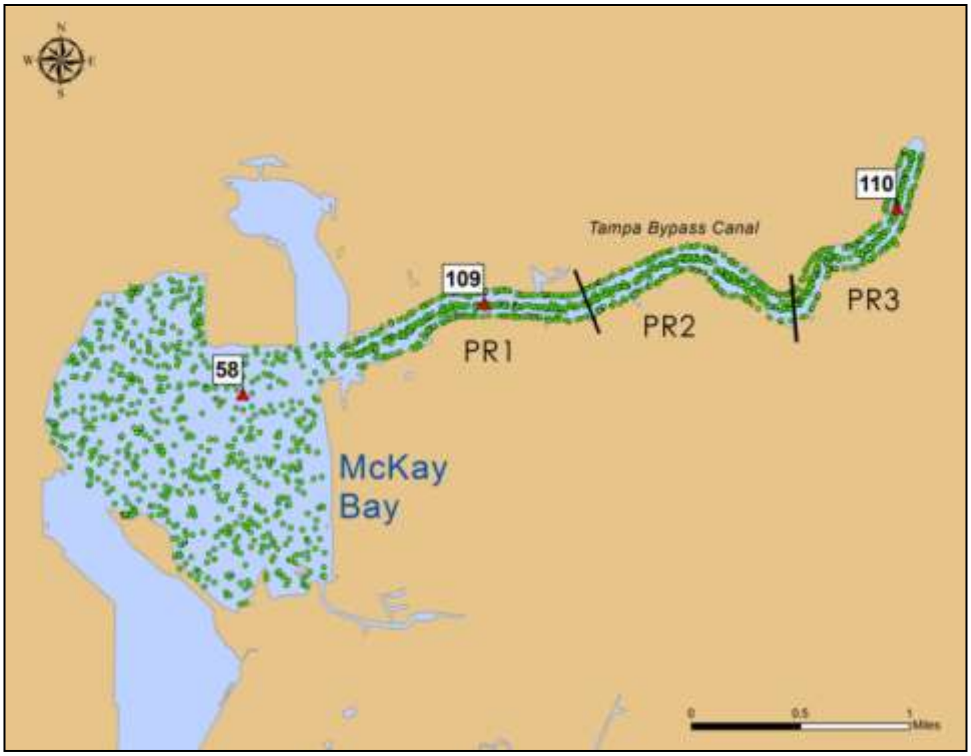


Figure 6 – Location of ambient water quality sampling stations in McKay Bay and the Palm River for EPC (red triangles) and HBMP (green dots)

The discussions and plots presented in Section 5.1 focus on the annual conditions for the nutrients and Chl a, since compliance is based upon annual values (geometric means and averages, respectively). Plots of the raw data are provided in Appendix B. For DO, the discussions and plots relate to the waterbody compliance with the DO criteria, using the present IWR assessment methodology.

5.1. Data Assessments

5.1.1. Fresh Water Inflow

Freshwater inflow is a key parameter driving hydrodynamics, transport, and water quality response in coastal embayments. For McKay Bay and the Palm River below structure S-160, freshwater inflows come from flows over S-160, as well as direct discharge from the watersheds below S-160 (see Figure 1). TBW has maintained records of the flow over S-160 for many years, but did a comprehensive rating of the flow over the structure in 2002. Figure 7 presents the measured flows over S-160 from 2002 to the present. The data show that, over the period of measurement, flows over S-160 have varied significantly. A key aspect of the flow conditions is based upon the development of a Minimum Flows and Levels (MFL) assessment of the TBC (SWFWMD, 2005). Subsequent to the implementation of the MFL, periods of zero flow occurred (post-August 2007). Prior to that date, flows did not generally fall below 5 million gallons per day (MGD).

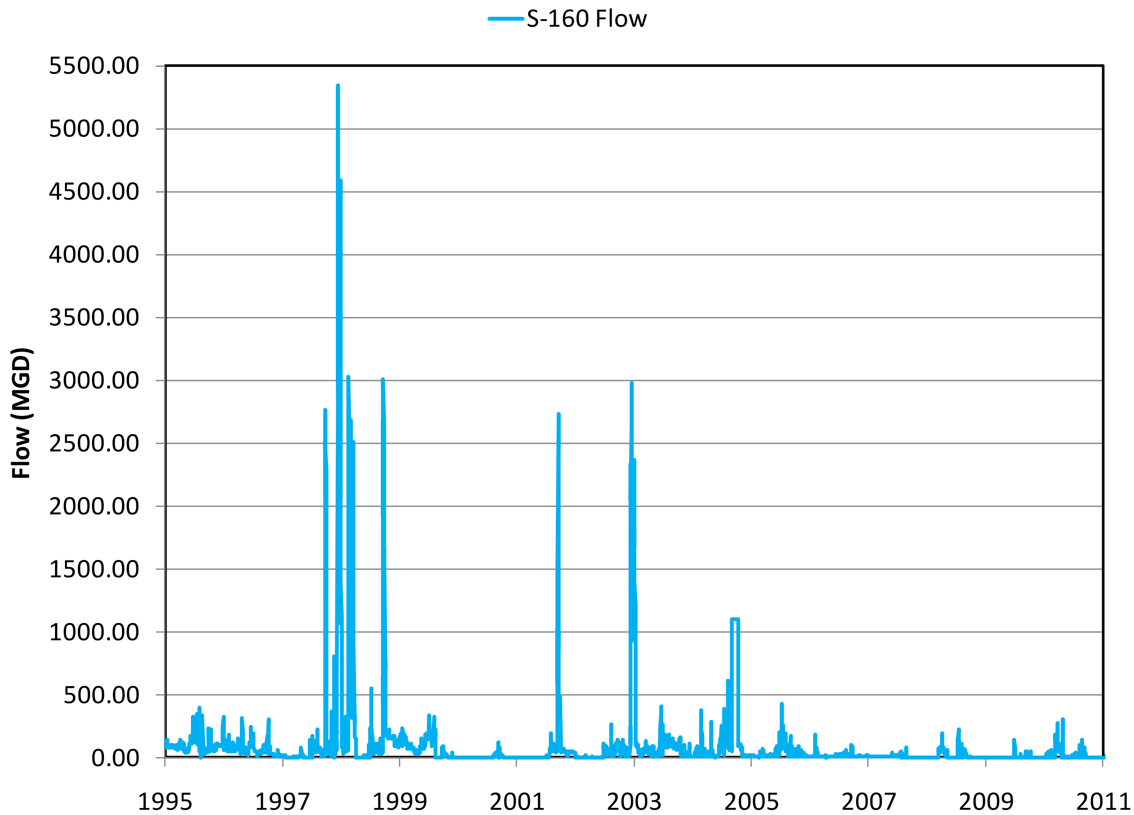


Figure 7 – Measured Flow over S-160 (2002 to Present)

5.1.2. Nutrients and Chl a

A time series plot of the annual average Chl a concentrations in McKay Bay, based on EPC 58 and the HBMP sampling stations, is presented in Figure 8. Additionally, a time series plot of the annual average Chl a concentrations in the downstream portion of the Palm River Tidal (EPC 109 and HBMP stations in PR1) is presented in Figure 9. As can be seen in both plots, the Chl a concentrations in the late 1970s and early 1980s were considerably higher than current conditions. A dramatic decrease was documented in the early 1980s, and a slow but steady decline in Chl a concentrations has continued to the present. As anticipated, the concentrations in the Palm River Tidal are slightly higher than those in McKay Bay; however, the pattern of a dramatic decline in the early 1980s and steady decline between mid-1980s and present is consistent in both plots (Figures 8 and 9). Though the HBMP sampling did not begin until 2000, the results of the HBMP sampling agree reasonably well with the EPC data. The HBMP samples show similar trends and overall magnitude with the EPC data, but generally are more variable. This is expected, given the sample locations within the more shallow areas and covering the entire water body. For the McKay Bay plot (Figure 8), the annual average target of 19.4 µg/L is shown as a line. The EPC data show no exceedances since 1998, whereas the HBMP data show only one exceedance in 2003. The data demonstrate that for Chl a, under present conditions, McKay Bay is at or below the Chl a target identified in Section 4.

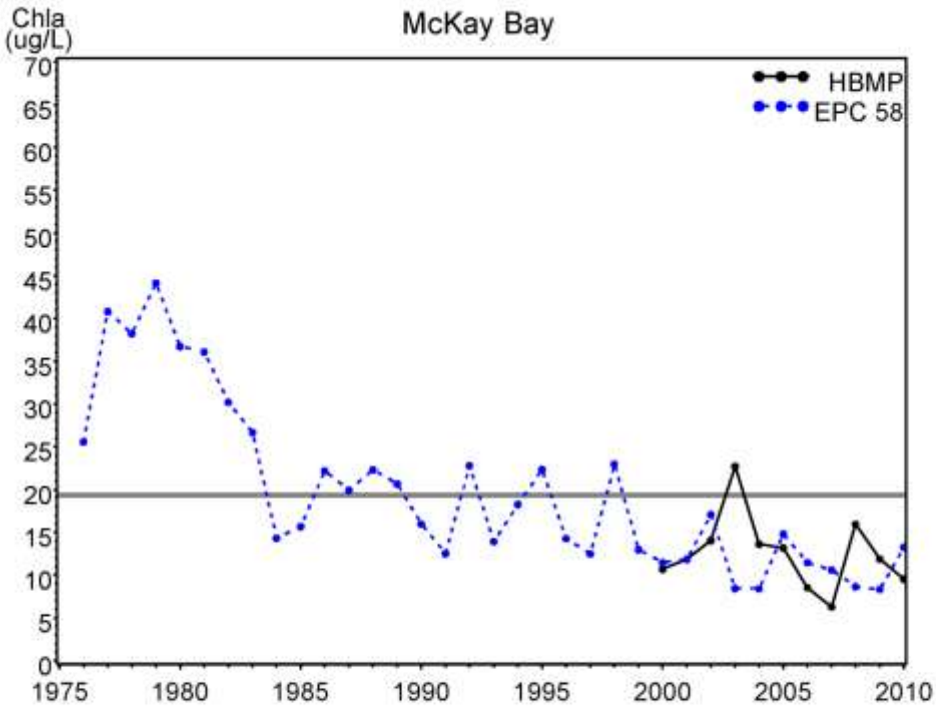


Figure 8 – Time series of annual average chlorophyll a concentrations in McKay Bay, based on EPC 58 (blue dotted line) and HBMP stations (black solid line).

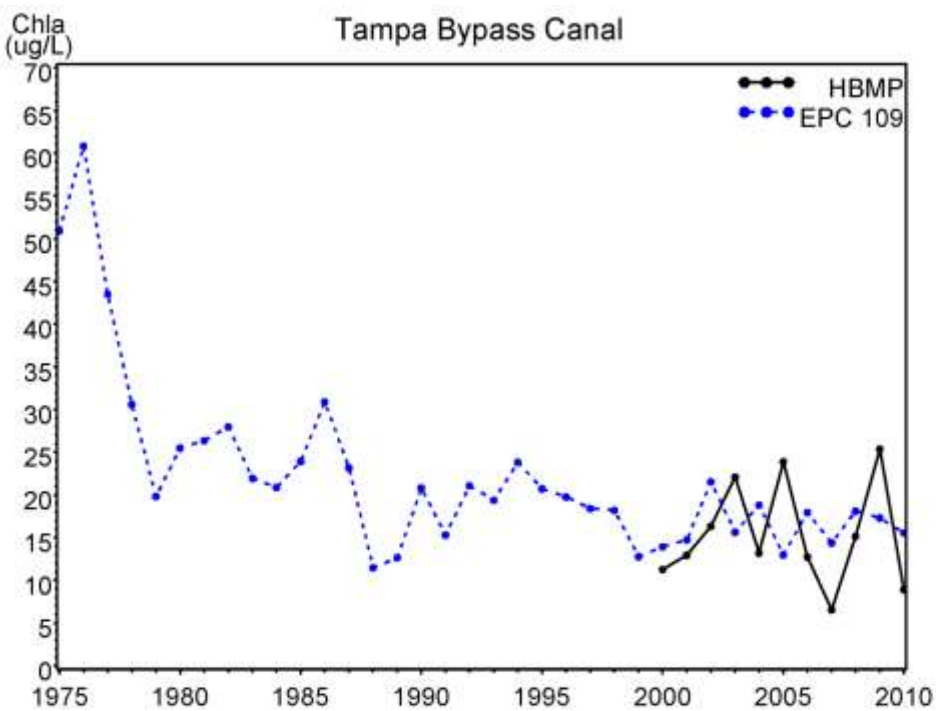


Figure 9 – Time series of annual average chlorophyll a concentrations in the Palm River, based on EPC 109 (blue dotted line) and HBMP stations (black solid line).

In support of the assertion of improving Chl a levels, Figure 10 presents annual average Secchi disc depths in McKay Bay and Palm River. Prior to 1980, annual average Secchi disc depths were less than 0.8 meter. Annual average Secchi disc depths increased substantially in the 1980s and early 1990s and have remained stable since. A steady increase can be seen in more recent years. The large changes in the late 1990s most likely reflect El Niño and high rainfall conditions that brought highly colored water from the Hillsborough River. Clarity is a key parameter for restoration within Tampa Bay, since light attenuation is the primary driving factor supporting seagrass recovery and a good indicator of water quality improvements.

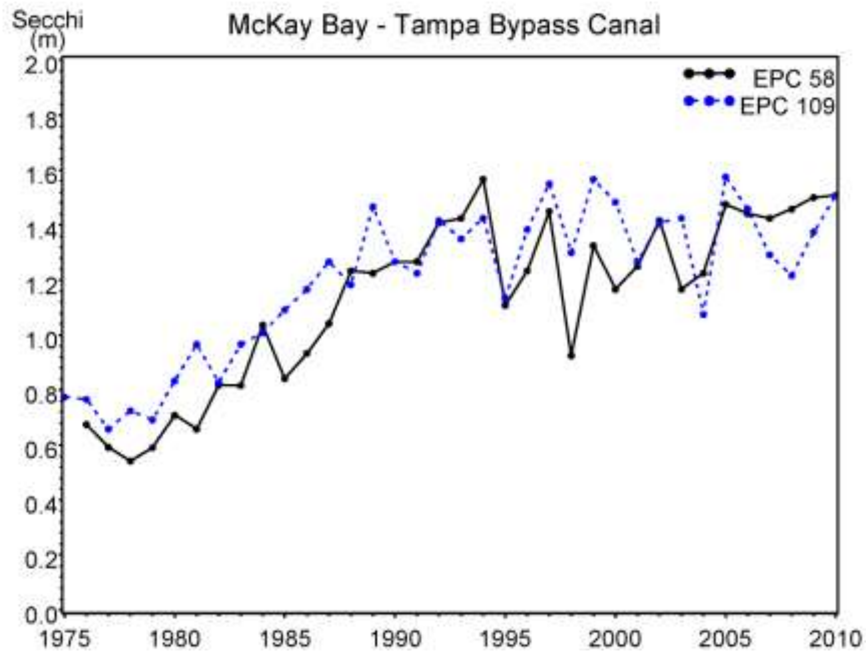


Figure 10 – Time series of annual average Secchi disc depths in McKay Bay and Palm River (EPC 58, black solid line).

Time series plots of annual geometric mean TN concentrations in McKay Bay and the Palm River Tidal are presented in Figure 11 and Figure 12, respectively. As was seen in the plots of Chl a concentrations, TN concentrations have declined since the 1970s. However, these reductions in TN concentrations were not quite as large relative to the reductions that were documented in Chl a concentrations during the same time period. Interestingly, the EPC and HBMP TN concentrations tend to diverge slightly in both McKay Bay and the Palm River Tidal, although the patterns among the sampling programs are similar (i.e., TN concentrations at EPC stations 58 and 109 continue to decline, while TN concentrations at the HBMP stations also decline over the period). The water depth at EPC Station 58 is typically greater than in the rest of the bay, located as it is in the dredged portion of McKay Bay. It is not surprising that there are some differences between water quality data collected at this location and those collected at the typically more shallow HBMP sites. TN data were not available for HBMP stations between May and December 2010 because of questionable ammonia values (Jenkins, pers. comm.). Therefore, annual geometric mean TN values were not calculated for the HBMP stations in 2010. For both the McKay Bay and Palm River Tidal plots, the annual geometric mean target of 1.01 mg/L, as identified in Section 4.4, is plotted as a line. The data show that this level has not been exceeded since the early 2000s in either waterbody, and both are meeting their targets under present conditions.

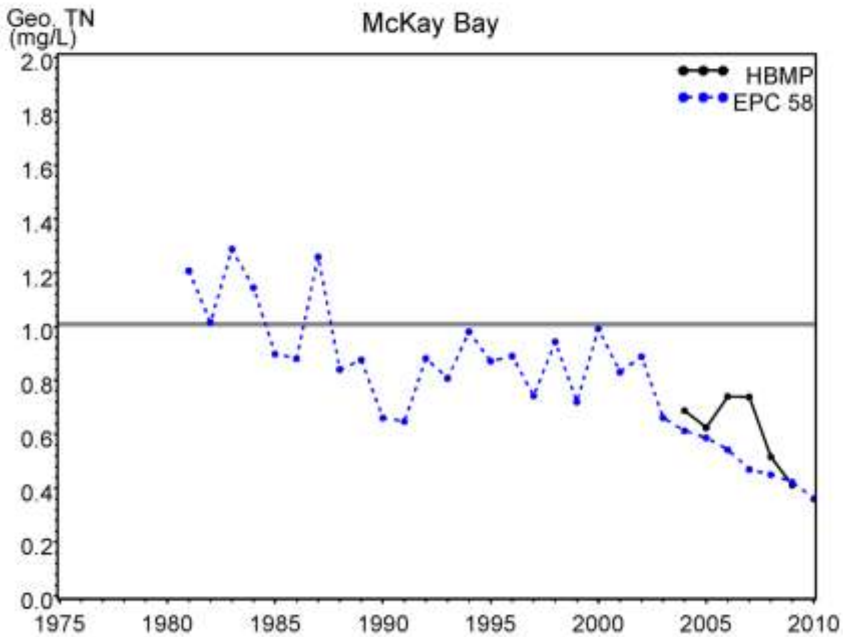


Figure 11 – Time series of annual geometric mean TN concentrations in McKay Bay, based on EPC 58 (blue dotted line) and HBMP stations (black solid line).

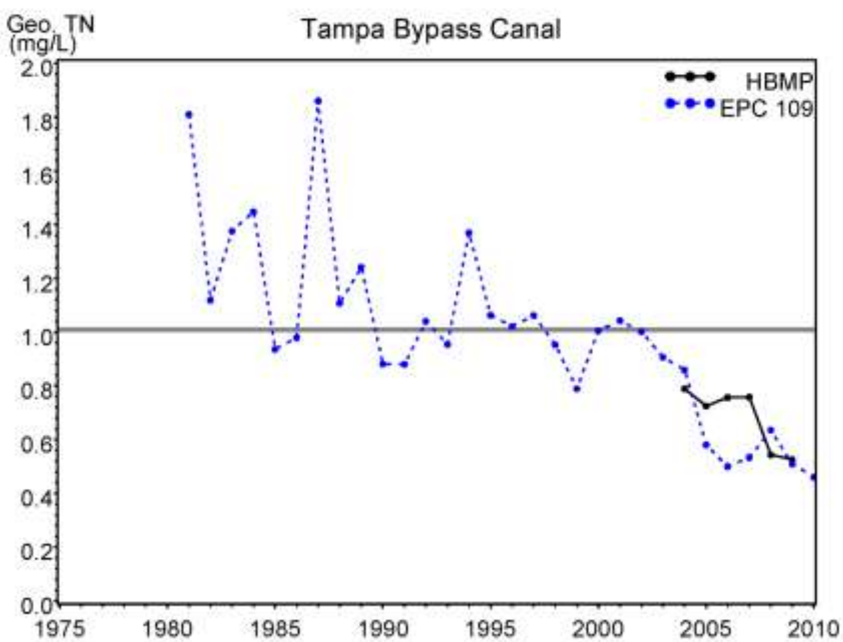


Figure 12 – Time series of annual geometric mean TN concentrations in the Tampa Bypass Canal, based on EPC 109 (blue dotted line) and HBMP stations (black solid line).

A time series plot of the annual geometric mean total phosphorus (TP) concentrations in McKay Bay based on EPC 58 and the HBMP sampling stations is presented in Figure 13. Additionally, a time series plot of the annual geometric mean TP concentrations in the downstream portion of the Palm River (EPC 109 and HBMP stations in PR1) is presented in Figure 14. As shown in both plots, TP concentrations in the late 1970s were considerably higher, typically near 1 mg/L or greater. Both plots include the TP target line. Since 2000, TP concentrations have been in the range of 0.2 to 0.3 mg/L. The results of the HBMP sampling agree very well with the EPC data.

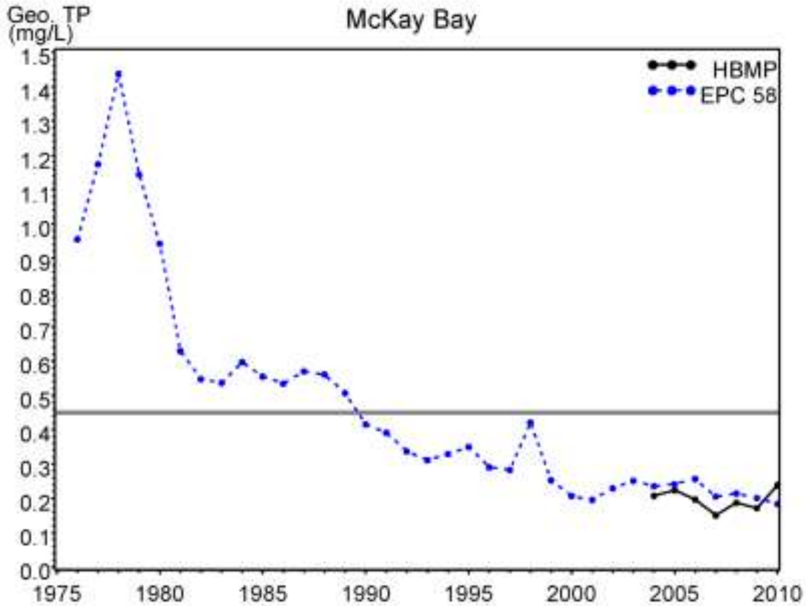


Figure 13 – Time series of annual geometric mean TP concentrations in McKay Bay, based on EPC 58 (blue dotted line) and HBMP stations (black solid line).

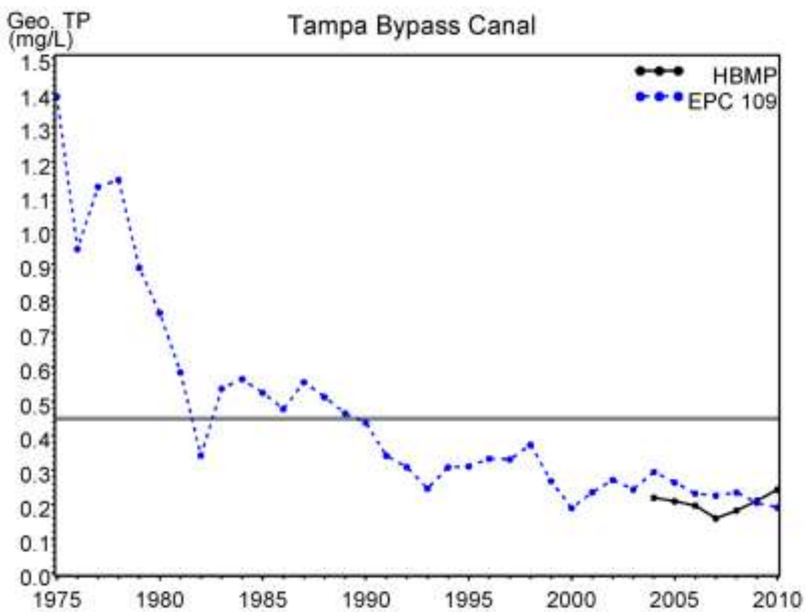


Figure 14 – Time series of annual geometric mean TP concentrations in the Tampa Bypass Canal, based on EPC 109 (blue dotted line) and HBMP stations (black solid line).

5.1.3. Dissolved Oxygen

In order to assess the DO conditions in McKay Bay and Palm River, the available DO data from the EPC and HBMP programs were analyzed. The raw data for the stations are plotted in Appendix B. The IWR methodology for assessing compliance with the DO criteria in marine waters identifies a waterbody as impaired if 10 percent of the measurements fall below the 4.0 mg/L criteria based upon a 90 percent confidence level. For the available data, this assessment was performed for all of the data from 2000 to the present. Given the lack of continuous sampling, the 5.0 mg/L daily average cannot be assessed against the available data. Table 3 presents the results of the analyses for the McKay Bay and Palm River Tidal WBIDs. For each year, and for each WBID, there are a significant number of measurements (more than 1000 for all years and all WBIDs, except Palm River in 2010, where 918 observations are available) so that the data represent an excellent statistical assessment of the DO conditions. Additionally, the inclusion of the HBMP data provides for full coverage of the areas of the WBIDs so the results should be fully representative of the conditions within each of the WBIDs.

The results show that both McKay Bay and Palm River Tidal are verified, based upon the historic and present conditions. While the percent DO exceedances in McKay Bay range from 8 percent up to 17 percent, with an average of 14 percent, the percent exceedances in the lower portions of Palm River range from 35 to 52 percent, with an average of 43 percent. The higher percent of exceedance of the criteria in the Palm River is expected, given that the channel has been significantly altered and has been dredged to depths generally not found in natural tidal tributaries in the Tampa Bay Area (15 to 20 feet). These depths increase the impacts of stratification and exacerbate the overall influence of the sediment oxygen demand (SOD) due to the depth needed for re-aeration to overcome the benthic oxygen demand.

Table 3 – Annual Percent of Dissolved Oxygen Measurements Less Than 4.0 (2000 to 2010)

Area		Year										
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
McKay Bay	# obs	1013	1319	1332	1338	1284	1250	1286	1312	1330	1319	1292
	# < 4mg/l	144	156	199	204	218	177	107	147	167	224	194
	% < 4mg/l	14%	12%	15%	15%	17%	14%	8%	11%	13%	17%	15%
Palm River	# obs	1220	1588	1586	1570	1571	1701	1576	1601	1447	1026	918
	# < 4mg/l	462	585	736	817	741	808	609	590	512	501	374
	% < 4mg/l	38%	37%	46%	52%	47%	48%	39%	37%	35%	49%	41%

5.2. Summary of Data Assessments

The analyses of the data identified that the present Chl a levels within McKay Bay are below the target identified in Section 4.0. Additionally, the TN and TP levels are below the target identified in Section 4.0 for downstream protection of Hillsborough Bay. In contrast, the DO data did show that both WBIDs are not meeting the present DO criteria as assessed under the

IWR. While both McKay Bay and Palm River Tidal have exceedances above the target 10 percent level, the exceedance percentages in Palm River are much higher due to the dredged depths.

6. Source and Load Assessment

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of pollutants in the watershed and the amount of loading contributed by each of these sources. Sources are broadly classified as either point or nonpoint sources. Nutrients can enter surface waters from both point and nonpoint sources.

6.1. Point Sources

A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater and treated sanitary wastewater must be authorized by National Pollutant Discharge Elimination System (NPDES) permits. NPDES-permitted discharges include continuous discharges such as wastewater treatment facilities as well as some stormwater-driven sources like municipal separate storm sewer systems (MS4s), certain industrial facilities, and construction sites greater than one acre.

6.1.1. Wastewater/Industrial Permitted Facilities

A TMDL wasteload allocation (WLA) is given to wastewater and industrial NPDES-permitted facilities discharging to surface waters within an impaired waterbody. Three permitted point sources discharge to the Palm River below S-160. This includes two municipal facilities (Hillsborough County Falkenburg Wastewater Treatment Plant, and Tampa Bay Regional Water Treatment Plant) and one industrial facility (Trademark Nitrogen). In addition, four permitted point sources discharge to East Bay, the WBID downstream of McKay Bay. These are Kinder Morgan Hartford Terminal, Kinder Morgan NH3 Facility, Kinder Morgan Port Sutton, Tampa Electric Co (TECO) Bayside, and Yara North America. Table 4 provides a summary with the facility name, permit number, facility type, and the allocation currently provided under the Tampa Bay Nitrogen Management Consortium RA Plan. Figure 15 provides the locations of the facilities.

In addition to these point sources, three fertilizer-handling facilities introduce nitrogen and phosphorus loadings to East Bay. These three facilities are CF Industries, Eastern Terminals, and CSX Rockport. As described in Poe et al. (2005), annual loading estimates from these facilities have been provided by facility operators for the TBEP and Tampa Bay Nitrogen Management Consortium for use in loading estimation and nitrogen allocations development associated with the RA. The CSX Rockport and Eastern facilities are east of the East Bay WBID 1584C, in WBID 1615, but the nutrient losses are associated with loading operations at a shared dock just to the west to ships in the East Bay WBID 1584C. Similarly, the CF Industries facility, while in the Ybor City Drain WBID 1584A, has losses associated with loading operations just to the northeast in the East Bay WBID 1584C.

Table 4 – NPDES Permitted Point Source Discharges and Fertilizer Handling Facilities that Discharge to the McKay Bay, Palm River Tidal, and East Bay Watershed

<table>
<tr><th>Name</th><th>Permit No.</th><th>WBID</th><th>Receiving Water</th><th>Type</th><th>RA Load Allocation</th></tr>
<tr><td>Hillsborough County Falkenburg WTP</td><td>FL0040614</td><td>1536A</td><td>Palm River</td><td>Domestic</td><td>15.2 tons TN/year</td></tr>
<tr><td>Trademark Nitrogen</td><td>FL0000647</td><td>1536A</td><td>Palm River</td><td>Industrial</td><td>0.04 tons TN/year *</td></tr>
<tr><td>Tampa Bay Regional WTP</td><td>FL0187691</td><td>1536A</td><td>Palm River</td><td>Domestic</td><td>1.5 tons TN/year</td></tr>
<tr><td>Kinder Morgan Hartford Terminal</td><td>FL0001643</td><td>1605D</td><td>East Bay</td><td>Industrial</td><td rowspan="3">75 tons TN/year **</td></tr>
<tr><td>Kinder Morgan NH3 Facility</td><td>FL0000264</td><td>1637</td><td>East Bay</td><td>Industrial</td></tr>
<tr><td>Kinder Morgan Port Sutton</td><td>FL0122904</td><td>1637</td><td>East Bay</td><td>Industrial</td></tr>
<tr><td>Tampa Electric Co (TECO) Bayside</td><td>FL0000809</td><td>1605D</td><td>East Bay</td><td>Industrial</td><td>0.76 tons TN/year *</td></tr>
<tr><td>Yara North America</td><td>FL0038652</td><td>1637</td><td>East Bay</td><td>Industrial</td><td>0.34 tons TN/year *</td></tr>
<tr><td>Eastern Terminal</td><td>--</td><td>1615</td><td>East Bay</td><td>Fertilizer Handling</td><td>5.6 tons TN/year</td></tr>
<tr><td>CF Industries</td><td>--</td><td>1584A</td><td>East Bay</td><td>Fertilizer Handling</td><td>3.4 tons TN/year</td></tr>
<tr><td>CSX</td><td>--</td><td>1615</td><td>East Bay</td><td>Fertilizer Handling</td><td>5.6 tons TN/year</td></tr>
</table>

*This tonnage is the portion of the federally recognized TMDL load assigned to this facility. The actual allocations for Trademark Nitrogen, Yara North America, and TECO Bayside are 0.004%, 0.03% and 0.07%, respectively, of the hydrologically affected load to Hillsborough Bay.

**Interim through 2012.

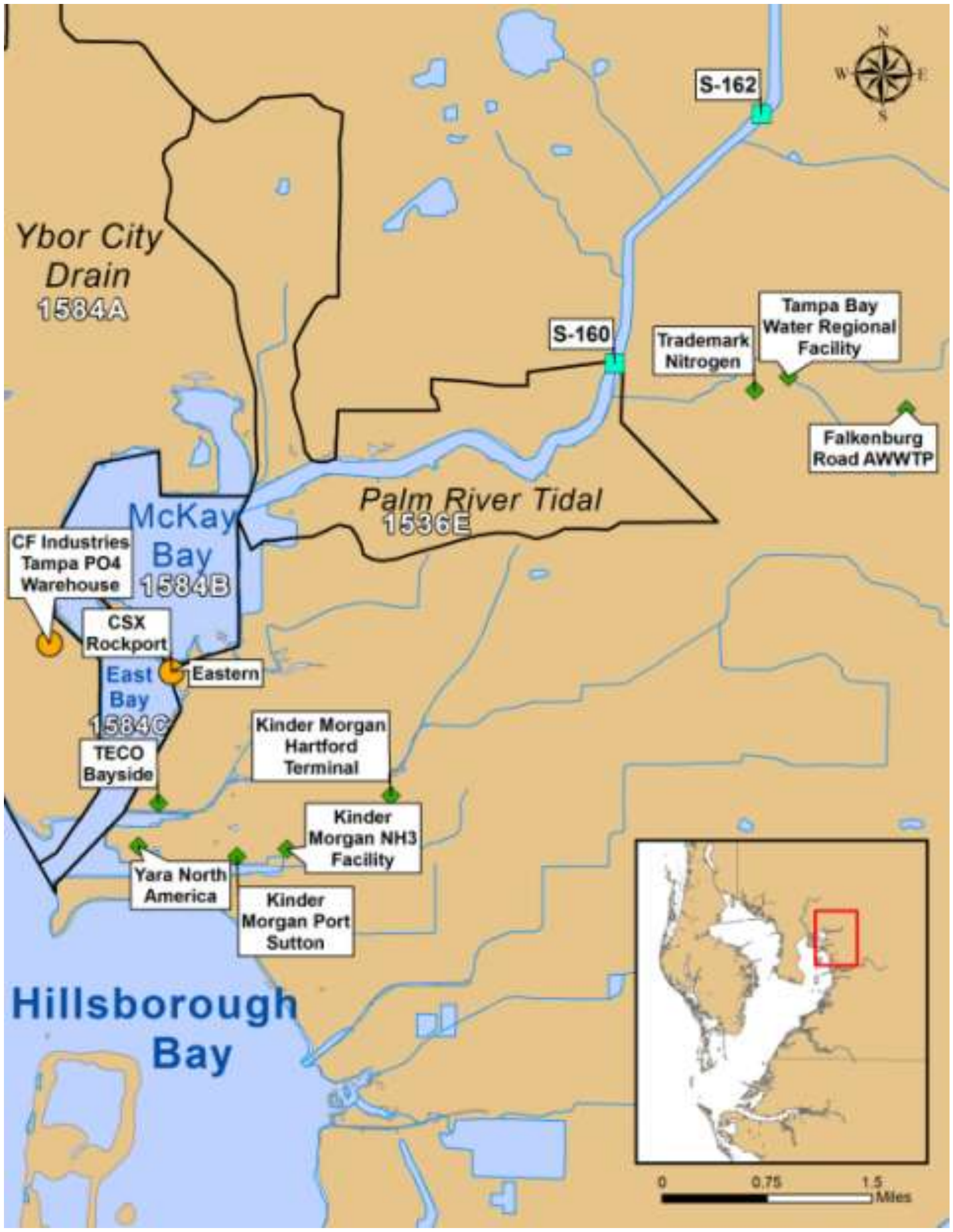


Figure 15 – Location of NPDES Permitted Point Source Discharges and Fertilizer Handling Facilities

6.1.2. Stormwater Permitted Facilities/MS4s

Municipal Separate Storm Sewer Systems (MS4s) are also regulated by the NPDES program. According to 40 CFR 122.26(b)(8), an MS4 is "a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

> (i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law)...including special districts under State law such as a sewer district, flood control district or

drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under Section 208 of the Clean Water Act that discharges into waters of the United States;

(ii) Designed or used for collecting or conveying storm water;

(iii) Which is not a combined sewer; and

(iv) Which is not part of a Publicly Owned Treatment Works.

MS4s may discharge nutrients and other pollutants to waterbodies in response to storm events. In 1990, USEPA developed rules establishing Phase I of the NPDES stormwater program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged from the MS4 into local waterbodies. Phase I of the program required operators of "medium" and "large" MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges from MS4s. Approved stormwater management programs for medium and large MS4s are required to address a variety of water-quality-related issues, including roadway runoff management, municipal-owned operations, hazardous waste treatment, etc. The watersheds within the McKay Bay, Ybor City Drain, and Palm River Tidal WBIDs and the watersheds that drain to these WBIDs are all within Phase I MS4 areas.

In October 2000, USEPA authorized FDEP to implement the NPDES stormwater program in all areas of Florida except Indian tribal lands. FDEP's authority to administer the NPDES program is set forth in Section 403.0885, Florida Statutes (FS). The three major components of NPDES stormwater regulations are:

- MS4 permits that are issued to entities that own and operate master stormwater systems, primarily local governments. Permittees are required to implement comprehensive stormwater management programs designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable.
- Stormwater associated with industrial activities, which is regulated primarily by a multisector general permit that covers various types of industrial facilities. Regulated industrial facilities must obtain NPDES stormwater permit coverage and implement appropriate pollution prevention techniques to reduce contamination of stormwater.
- Construction activity general permits for projects that ultimately disturb one or more acres of land and that require the implementation of stormwater pollution prevention plans to provide for erosion and sediment control during construction.

Several Phase I MS4 permits have been issued within the McKay Bay/TBC watershed. Plant City, Hillsborough County, and the Florida Department of Transportation are co-permittees under Permit FLS000006. The city of Tampa and the city of Temple Terrace have individual permits, FLS000008 and FLS000009, respectively. The entire watershed lies within the jurisdiction of these three permits.

6.2. Nonpoint Sources

Nonpoint sources of pollution are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For nutrients, these sources include runoff of agricultural fields, golf courses, and lawns; septic tanks; and residential developments outside of MS4 areas. Nonpoint source pollution generally involves a buildup of pollutants on the land surface that wash off during rain events and, as such, represent contributions from diffuse sources, rather than from a defined outlet. Potential nonpoint sources are commonly identified, and their loads estimated, based on land cover data. Most methods calculate nonpoint source loadings as the product of the water quality concentration and runoff water volume associated with certain land use practices. The mean concentration of pollutants in the runoff from a storm event is known as the event mean concentration (EMC).

Figure 5 provided a map of the land use in the McKay Bay/TBC watershed. Table 1 provided a breakdown of the land uses by acres and percent of the watershed area. The predominant land use is urban. The following sections are organized by land use. Each section provides a description of the land use, the typical sources of nutrient loading (if applicable), and a general discussion of the TN and TP EMCs for the specific land use.

6.2.1. Urban Areas

Urban areas include land uses such as residential, industrial, extractive, and commercial. Land uses in this category typically have somewhat high TN EMCs and average TP EMCs. Nutrient loading from MS4 and non-MS4 urban areas is attributable to multiple sources including stormwater runoff, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals.

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as outlined in Chapter 403 FS, was established as a technology-based program that relies upon the implementation of Best Management Practices (BMPs) that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, FAC.

Florida's stormwater program is unique in having a performance standard for older stormwater systems that were built before the implementation of the Stormwater Rule in 1982. This rule states: "the pollutant loading from older stormwater management systems shall be reduced as needed to restore or maintain the beneficial uses of water." [FAC 62-40-.432(2)(c)]

Nonstructural and structural BMPs are an integral part of the state's stormwater programs. Nonstructural BMPs, often referred to as "source controls," are those that can be used to prevent the generation of nonpoint source pollutants or to limit their transport offsite. Typical nonstructural BMPs include public education, land use management, preservation of wetlands and floodplains, and minimization of impervious surfaces. Technology-based structural BMPs are used to mitigate the increased stormwater peak discharge rate, volume, and pollutant loadings that accompany urbanization.

Urban land uses, including residential and commercial developments, are likely the most important nonpoint sources of nutrients and oxygen-demanding substances in the McKay Bay/TBC watershed. Land uses in this category comprise 71 percent of the overall watershed area and 85 percent of the watershed below S-160.

Onsite Sewage Treatment and Disposal Systems (Septic Tanks)

Leaking septic tanks or onsite sewage treatment and disposal systems (OSTDs) can contribute to nutrient loading in urban areas. Water from OSTDs is typically released to the ground through onsite, subsurface drain fields or boreholes that allow the water from the tank to percolate (usually into the surficial aquifers) and either transpire to the atmosphere through surface vegetation or add to the flow of shallow ground water. When properly sited, designed, constructed, maintained, and operated, OSTDs are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTD receives natural biological treatment in the soil and is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, OSTDs can be a source of nutrients, pathogens, and other pollutants to both ground water and surface water.

6.2.2. Rangeland and Pasture

Rangeland and pastures includes herbaceous, scrub, disturbed scrub, and coastal scrub areas. EMCs for rangeland are about average for TN and low for TP. Land uses in this category comprise 12 percent of the overall watershed area and 7 percent of the watershed below S-160.

6.2.3. Upland Forests and Barren Land

Upland forests include flatwoods, oak, various types of hardwoods, conifers and tree plantations, as well as unmanaged open land. Wildlife, located within forested areas, deposit their feces onto land surfaces where it can be transported to nearby streams during storm events. Generally, the pollutant load from wildlife is assumed to represent background concentrations. EMCs for these land uses are low for both TN and TP. Barren land includes beaches, borrow pits, disturbed lands, and fill areas. EMCs for barren lands tend to be higher in TN. Land uses in this category comprise 3 percent of the overall watershed area and 1 percent of the watershed below S-160.

6.2.4. Water and Wetlands

Water and wetlands are generally nutrient sinks. While at times the load out can be significant, overall, the uptake is greater than the discharge, therefore wetlands tend to be nutrient sinks. Land uses in this category comprise 12 percent of the overall watershed area and 7 percent of the watershed below S-160.

6.2.5. Agricultural

Agricultural land uses defined herein represent active agricultural areas primarily for the growing and harvesting of crops. Generally, agricultural areas have relatively high EMCs for both nitrogen and phosphorus. Land uses in this category comprise less than 1 percent of the watershed overall and below S-160.

7. Analytical Approach

In the development of a TMDL, there needs to be a method for relating current loadings to the observed water quality problem. This relationship could be statistical (regression for a cause and effect relationship), empirical (based on observations not necessarily from the waterbody in question), or mechanistic (physically and/or stochastically based) that inherently relate cause and effect using physical and biological relationships.

Two mechanistic models and one empirical model were used in the development of this TMDL. The first model is an empirical watershed-loading model developed as part of the Tampa Bay Nitrogen Management Consortium RA Plan. The second two models are the hydrodynamic model Environmental Fluid Dynamics Code (EFDC) and the receiving water quality model Water Quality Analysis Simulation Program. (WASP). The hydrodynamic and water quality models are capable of integrating the loadings (hydrologic and nutrients) from the watershed model to predict the water quality in the receiving waterbody.

The period of simulation for the model calibration was January 1, 2003 to January 1, 2008. The models were used to predict time series for nitrogen, phosphorus, BOD, DO, and Chl a. The models were calibrated using the loads and meteorologic conditions from 2003 through 2007 and were then used to evaluate improvements in water quality as function of reductions in loadings and associated responses in the benthic conditions.

A detailed modeling report outlining the full model calibration, assumptions, coefficients, and inputs for the EFDC and WASP models is presented in Appendix C. The models are summarized in this section, along with a discussion of the development of the loads.

7.1. Watershed and Atmospheric Load Development

Constituent loadings to the McKay Bay / TBC system were defined for the following sources:

- Flows over S-160 from the upper watershed
- Nonpoint sources from the ungaged area below S-160

- Permitted point sources
- Atmospheric deposition

Loading estimates from each source include the following constituents; ammonia nitrogen (NH_3), nitrate-nitrite nitrogen (NO_2NO_3), organic nitrogen, ortho-phosphorous (PO_4), organic phosphorous, ultimate carbonaceous biochemical oxygen demand (CBODu), dissolved oxygen (DO), and phytoplankton (chlorophyll a). The methodologies for deriving the constituent loadings from each source are described in the following sections.

7.1.1. Flows and Loads Over S-160

The flows over S-160 were taken from the measured data by TBW. In 2002, TBW updated its flow ratings for this structure and since 2002, has highly accurate measured flows going over the structure. Daily values were used in the model. A plot of the data was provided in earlier sections in Figure 7.

Constituent loadings from S-160 were estimated as the product of the measured daily flow over the structure and the concentrations of constituents upstream of the structure. Constituent concentrations were obtained from EPC Station 147, which is located in the TBC lower pool above S-160. The EPC data were monthly and the flows were daily, so the concentrations between the measurements were determined using linear interpolation. Appendix C presents the time series of these loads.

7.1.2. Nonpoint Sources below S-160

Freshwater inflows downstream of S-160 result in loadings of constituents from nonpoint sources. Hydrologic loads (daily total flow) were provided by the SWFWMD Ecological Evaluation Section (M. Heyl, pers. comm.). These hydrologic loads were used in the MFL assessment for the TBC performed by Luther and Meyers (2005). The hydrologic loads were multiplied by land use-specific constituent concentrations to derive loadings. The pollutant concentrations were the same as those used in estimating baywide loadings to Tampa Bay for the Tampa Bay Estuary Program (Poe et al., 2005). This approach provided daily load estimates. Appendix C presents the times series of these loads.

7.1.3. Permitted Point Sources and Incidental Discharges

The permitted point sources discharging to Palm River and East Bay were listed in Table 4 and plotted in Figure 15. Three point sources discharge to the Palm River Tidal WBID: Hillsborough County's Falkenburg facility, Trademark Nitrogen, and TBW's Regional Treatment Plant. These three facilities discharge to the Palm River Tidal WBID just downstream of S-160. Discharge volume and concentration data were obtained from FDEP (N. Cornwell, pers. comm.). As data allowed, daily loads were calculated for each of these sources by multiplying the flow and the concentrations for each day. Since daily estimates were not available for Trademark Nitrogen, daily estimates were derived from the monthly loads.

Five point sources discharge to East Bay (1584C): Kinder Morgan Hartford Terminal, Kinder Morgan NH3 Facility, Kinder Morgan Port Sutton, Tampa Electric Co (TECO) Bayside, and Yara North America. These facilities discharge to the lower end of East Bay. Monthly discharge volume and concentration data were obtained from FDEP (N. Cornwell, pers. comm.). These monthly values were then converted to daily loads for the modeling.

In addition to these point sources, three fertilizer-handling facilities introduce nitrogen and phosphorous loadings to East Bay. These three facilities are CF Industries, Eastern Terminals, and CSX Rockport. As described in Poe et al. (2005), annual loading estimates from these facilities are provided by facility operators. These annual loads were used to estimate daily loads by assuming a uniform load throughout the year.

7.1.4. Summary of Point Source and Nonpoint Source Loads

Table 5 provides a summary of the annual point and nonpoint source loads to the model. The loads are presented as pounds per year to or from the following:

- Over S-160 into the upstream reach of the tidal Palm River
- Discharges directly to Palm River from point and nonpoint sources
- Total load to Palm River including upstream loads
- Discharges directly to McKay Bay from point and nonpoint sources
- Total loads to McKay Bay including upstream loads
- Loads to East Bay
- Total loads to the full system including East Bay, McKay Bay, and the Palm River

Examination of the load distribution shows that for the Palm River, 78 percent and 86 percent of the loads for TN and TP, respectively, come over S-160 for the period from 2003 to 2007, with most of the load from nonpoint sources. For McKay Bay, 70 percent and 81 percent of the loads for TN and TP, respectively, come over S-160 on average during the period from 2003 to 2007, with nearly all of these loads as nonpoint sources. There were significant point source load discharges to East Bay during the period of the simulation. The loads to East Bay are important to the overall system since tidal action transports load into East Bay, and modeling sensitivity analyses showed that impacts to DO conditions in East Bay influence the DO conditions in McKay Bay. With the inclusion of the point source loads to East Bay, point sources make up more than 50 percent of the total loads to the system from 2003 to 2007.

Table 5 – Summary of Annual Loads to Model for the Baseline Condition (Point and Nonpoint Sources)

Area	Type	TN (lb/year)					TP (lb/year)				
		2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
Over S-160	NPS	402143	615881	195823	36891	11744	87196	243290	26459	5039	2597
	PS	0	0	0	0	0	0	0	0	0	0
Palm River Direct Loads	NPS	73572	88561	79807	64321	58974	11583	13934	12559	10089	9226
	PS	130	231	105	56	42	215	34	29	29	20
Total to Palm River	NPS	475714	704442	275630	101212	70718	98779	257224	39018	15128	11823
	PS	130	231	105	56	42	215	34	29	29	20
McKay Bay Direct Loads	NPS	37499	45355	40532	33041	30012	5902	7137	6378	5183	4695
	PS	0	0	0	0	0	0	0	0	0	0
Total to McKay Bay	NPS	513213	749797	316162	134253	100730	104681	264361	45396	20311	16518
	PS	130	231	105	56	42	215	34	29	29	20
East Bay Direct Loads	NPS	62471	83500	35389	26740	25107	10238	13849	5870	4359	4103
	PS	509278	927132	236040	702261	102988	391476	212487	166955	158550	151991
Total Load	NPS	575684	833296	351552	160993	125837	114920	278210	51265	24670	20621
	PS	509407	927363	236146	702317	103030	391691	212520	166985	158579	152012

7.1.5. Atmospheric Deposition

Atmospheric deposition consists of delivery of nitrogen and phosphorus directly to the water surface of the system. The methodology to estimate the atmospheric deposition to McKay Bay, East Bay, and the Palm River Tidal is the same as that employed for the baywide loadings for the Tampa Bay Estuary Program (Poe et al., 2005). Precipitation volumes were derived from the rainfall surface developed for the bay wide loadings, which utilizes more than 20 National Weather Service (NWS) sites to derive location-specific precipitation. Precipitation concentration data and wet to dry deposition ratios specific to Tampa Bay were obtained from the Tampa Bay Atmospheric Deposition Study, as described in Poe et al. (2005).

7.2. Environmental Fluid Dynamics Code (EFDC)

The EFDC model was utilized to simulate the hydrodynamics and transport within the Palm River, McKay Bay, and East Bay and into Hillsborough Bay. The model was used to simulate the period from 2003 to 2007 for model calibration which was identified as the baseline condition. For the future condition and natural condition simulations presented later, the same tides and meteorologic conditions were utilized, only the freshwater inflow was varied. Appendix C provides a complete and detailed discussion of the model set-up and calibration.

7.3. Water Quality Analysis Simulation Program (WASP)

The WASP model was utilized to simulate the receiving water quality within the Palm River Tidal, McKay Bay, and East Bay and into Hillsborough Bay. The model was used to simulate the period from 2003 to 2007 for model calibration. The same set of general meteorologic conditions was used for the future and natural condition simulations to assess the impacts from load and flow reductions. Appendix C provides a complete and detailed discussion of the model set-up and calibration.

7.4. Load Reduction Evaluations under Present DO Criteria

The previous sections and Appendix C describe the development of the system of models to assess the changes in the water quality within McKay Bay and Palm River Tidal. Section 5 shows that both systems are meeting the proposed targets for Chl a and nutrients. Therefore, for the TMDL, DO was the driving response parameter for the load reduction scenarios.

Using the calibrated model, various hydrologic and constituent loading conditions were simulated using the baseline boundary conditions (for tides and meteorology) from the 2003 to 2007 period to identify the sensitivity of the model response in DO to the loadings. Through the sensitivity analyses, it was determined that the primary parameter that has an impact on DO conditions is the SOD. The DO predictions by the model are not very sensitive to load reductions. To get a significant level of DO response, it is necessary to have a commensurate reduction in SOD.

For the development of the TMDL, three model scenarios were evaluated. These are the *Baseline* condition, the *Future* condition, and a *Natural* condition. The following paragraphs describe each of these conditions.

The *Baseline* condition is the actual 2003 to 2007 period. This period reflects the full range of hydrologic conditions, with higher flows at the beginning of the simulation and a very dry period at the end of the simulation. This condition is presented fully in Appendix C. The loads for this condition are presented in Table 5.

The *Future* condition was established based upon a number of projected changes in load and flow conditions in the system. The changes simulated include:

- Post-MFL flow conditions over S-160
- Projected load reductions in the point sources to East Bay under the Tampa Bay Nitrogen Management Consortium RA Plan

An updated MFL was established for the TBC in late 2007 that significantly altered the flow over S-160. Utilizing an assessment performed by TBW (Hazen and Sawyer, 2010) a post-MFL expected condition was established.

Although the *Future* scenario represents a five-year period in the future, the model was actually run for a six-year period. Output from the first year of the model run was not included in the analyses to allow for model spinup. The daily nonpoint source flows for the ungaged area downstream of S-160 for the *Future* scenario were assumed to be unchanged from the baseline nonpoint source flows, since little change in land use is this area is anticipated in the future. Therefore, the future nonpoint source flows for the area downstream of S-160 were the same as the nonpoint source flows from the 2003-2007 period. Because the operation of TBC is anticipated to change due to management actions, a suitable estimate of future flows over S-160 was needed. Hazen and Sawyer (2010) developed a stochastic model to predict S-160 flows under a wide range of rainfall conditions. These model simulations account for the future management actions affecting the TBC and flows over S-160. Twenty-five simulations of 300 years each were run to better understand the anticipated impact of management actions. To identify a period that was similar to 2003-2007 in terms of rainfall, annual total and 6-year running average rainfalls were calculated. After identifying the simulated periods that had 6-year running average rainfalls most similar to actual 2003-2007 rainfalls, the rainfalls in individual years were compared and the simulated period with the smallest absolute difference between all of actual and simulated years was selected.

This *Future* condition represents the long-term change in flows post-MFL in comparison to pre-MFL conditions. Overall, this change represents an approximate 30 percent overall reduction in flows over S-160, along with the accompanying load changes. For the *Future* condition, the concentrations of the inflowing TN and TP levels are not assumed to change from the baseline, so that all reduction comes primarily from changes in flows.

In addition to the changes in flows and loads over S-160, under the Tampa Bay Nitrogen Management Consortium RA Plan, load reductions are projected for the point sources discharging to East Bay. As East Bay has a significant impact upon the DO conditions in McKay Bay, and considering that loads to East Bay do impact McKay Bay due to tidal transport, these load reductions are important. Table 6 presents the revised loading conditions for the *Future* condition. In all model boundary conditions other than the load reductions described, the *Future* condition simulation is identical to the Baseline condition simulation.

The primary mechanism impacting the DO in the model is the SOD, so for the *Future* condition simulation a commensurate reduction in the SOD levels is required. SOD is generally responsive to the long-term loading conditions in a system. Table 7 presents the annual average loading conditions for the Baseline and Future scenarios, along with the percent reductions for both TN and TP. Using the baseline SOD levels presented within Appendix C, a percent reduction was applied that matches the reduction in loading for each individual WBID. The percent reductions were taken from the TN loads as TN is the limiting parameter in the system. As such, a 37 percent reduction in SOD was applied in the Palm River, a 33 percent reduction was applied in McKay Bay, and a 60 percent reduction was applied in East Bay.

The *Natural* condition represents a simulation with the same input conditions as the Future condition simulations for tides, meteorology, and model input conditions. For the hydrologic and water quality constituent loadings, watershed model simulations provided by EPA where the land-use conditions in Ybor City Drain, and the entire Palm River Tidal watersheds were set to non-anthropogenic uses and the simulations run for the 2003 to 2007 time period. In this run all point source loads were removed. In addition, the SOD in the model segments was set to a natural condition based upon the levels of load reduction with the smallest allowable SOD set to 0.5 gm/m^2/day. This was deemed a baseline natural SOD.

Figures 16 and 17 present plots of the daily average and hourly DO for the *Baseline* and the *Future* condition for McKay Bay and Palm River Tidal. For the daily average DO plots, the 5.0 mg/L standard is shown as a line. For the hourly DO the 4.0 mg/L criteria is shown. The results show that for both conditions while the 4.0 mg/L standard is met overall under the Future condition, the 5.0 mg/L daily average standard is not met in both McKay Bay and the Palm River Tidal WBIDs. Additionally, runs made under the Natural condition also showed that for both systems, the 5.0 mg/L standard cannot be met.

7.5. Load Reduction Evaluations under Existing Standard

At present Florida is in the process of revising its DO criteria for fresh and marine waters. As such, an assessment of the Baseline and Future condition simulations was done against the proposed DO criteria. The criteria (for marine waters) utilize the Virginian Province approach and establishes percent saturation values for varying periods of exposure. The criteria are;

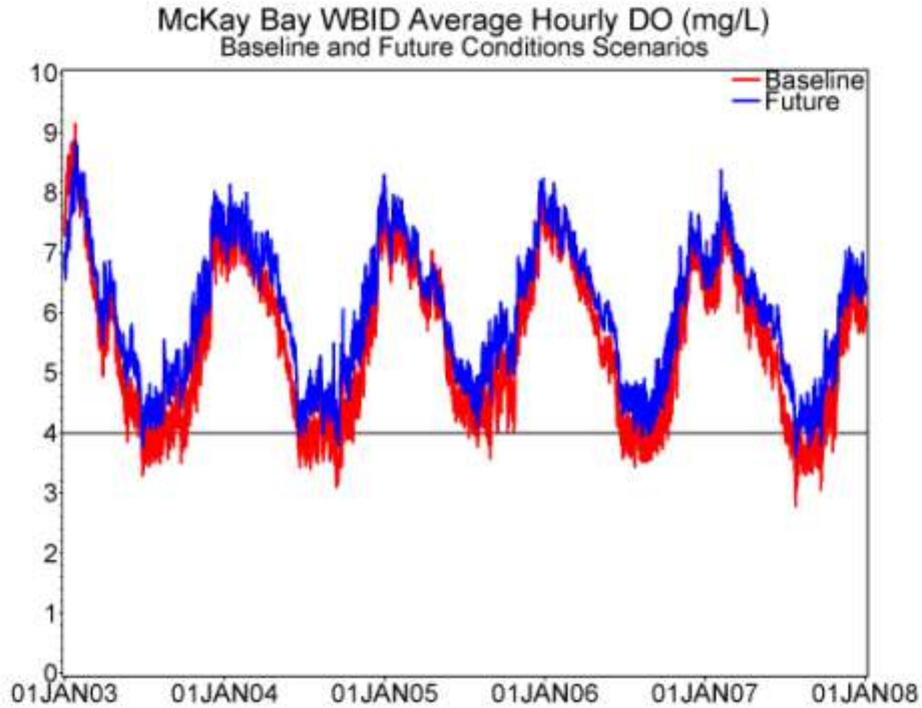
- 1-day average percent saturation minimum of 41.7%
- 7-day average percent saturation minimum of 51%
- 30-day average percent saturation minimum of 56.5%

Table 6 – Summary of Annual Loads to Model for the Future Condition (Point and Nonpoint Sources)

Area	Type	TN (lb/year)						TP (lb/year)				
		2003	2004	2005	2006	2007		2003	2004	2005	2006	2007
S-160	NPS	177559	411504	47522	8117	18370		43134	92482	10633	1064	3344
	PS	0	0	0	0	0		0	0	0	0	0
TBC	NPS	73572	88561	79807	64321	58974		11583	13934	12559	10089	9226
	PS	130	231	105	56	42		215	34	29	29	20
Total to Palm River	NPS	251131	500064	127329	72438	77344		54717	106416	23191	11153	12570
	PS	130	231	105	56	42		215	34	29	29	20
McKay Bay	NPS	37499	45355	40532	33041	30012		5902	7137	6378	5183	4695
	PS	0	0	0	0	0		0	0	0	0	0
Total to McKay Bay	NPS	288630	545419	167861	105479	107356		60619	113553	29570	16336	17265
	PS	130	231	105	56	42		215	34	29	29	20
East Bay	NPS	62471	83500	35389	26740	25107		10238	13849	5870	4359	4103
	PS	73940	73612	69448	66786	62038		391476	212487	166955	158550	151991
Total Load	NPS	351101	628919	203250	132219	132463		70857	127402	35439	20695	21368
	Pt Src	74069	73843	69553	66842	62079		391691	212520	166985	158579	152012

Table 7 – Baseline versus Future Average Loading

WBID	Baseline Total (lb)		Future Total		Percent Change	
	TN	TP	TN	TP	TN	TP
Palm River	325,656	84,460	205,774	4,1675	-37%	-51%
McKay Bay	362,944	90,319	243,062	47,534	-33%	-47%
East Bay	905,125	314,295	358,868	271,510	-60%	-14%



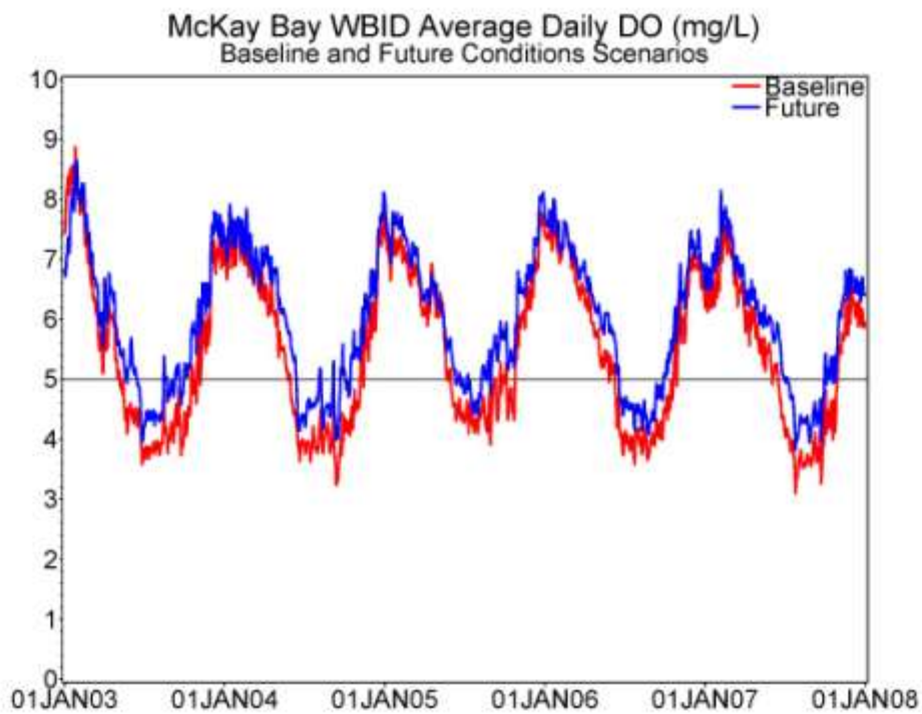
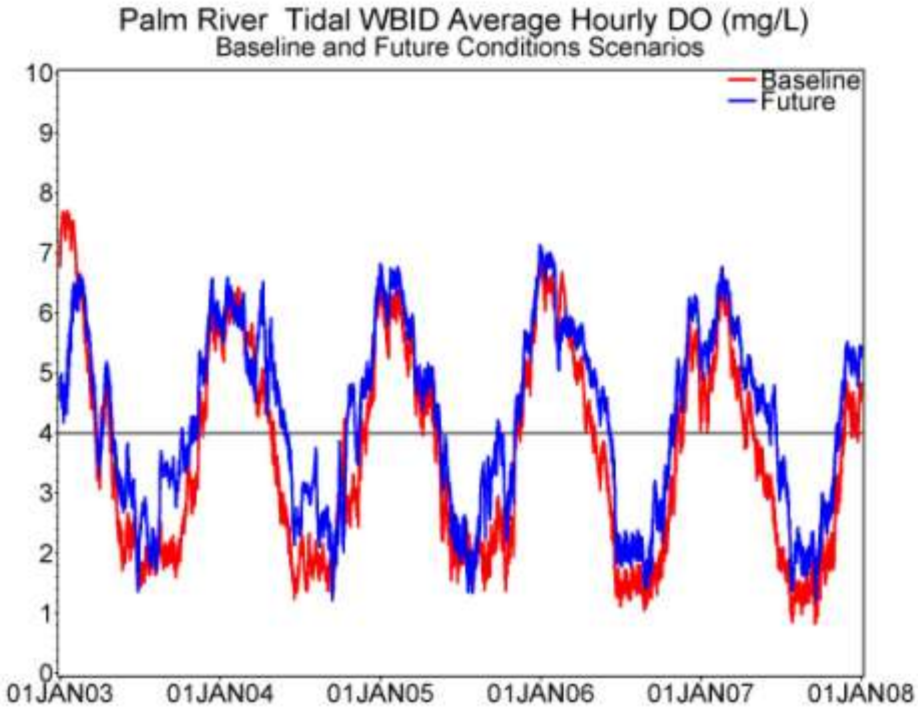


Figure 16 – Plots of Hourly and Daily Average DOs in McKay Bay by Year for Baseline and Future Conditions



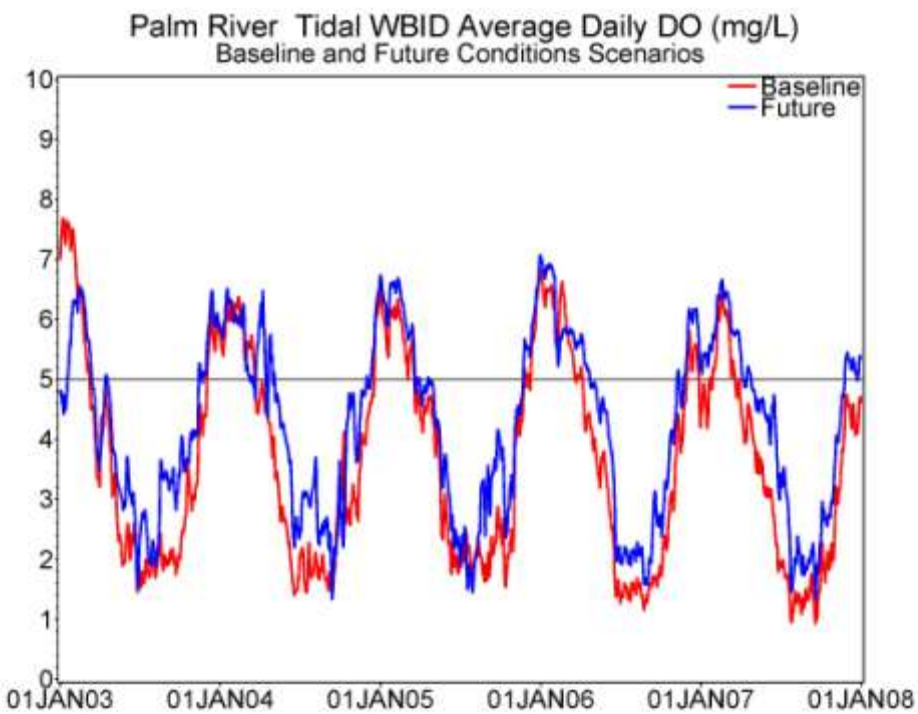


Figure 17 – Plots of Hourly and Daily Average DOs in Palm River Tidal by Year for Baseline and Future Conditions

Tables 8a and 8b present the results of the assessment against the proposed criteria. The tables show that under the *Baseline* conditions both McKay Bay and the Palm River Tidal do not meet the proposed criteria. Under the *Future* condition McKay Bay would be in compliance with the new criteria while the Palm River Tidal would not meet the proposed criteria. These results are presented within the TMDL document in recognition of the potential proposed standards but are not utilized in the determination of the TMDL presented in Section 8.

Table 8a - Exceedances of FDEP Proposed Revised DO Criteria for Baseline Conditions, for 2003-2007

DO Saturation Criteria	McKay Bay WBID	Palm River Tidal WBID
1-Day Average (41.7%)	3 (0.2%)	816 (44.7%)
7-Day Average (51.0%)	24 (1.3%)	985 (54.1%)
30-Day Average (56.5%)	163 (9.1%)	1143 (63.6%)

Table 8b – Exceedances of FDEP Proposed Revised DO Criteria for Future Conditions, for 2003-2007

DO Saturation Criteria	McKay Bay WBID	Palm River Tidal WBID
1-Day Average (41.7%)	0 (0%)	462 (25.3%)
7-Day Average (51.0%)	0 (0%)	730 (40.1%)
30-Day Average (56.5%)	0 (0%)	863 (48.0%)

8. TMDL Determination

The TMDL for a given pollutant and waterbody is comprised of the sum of individual WLAs for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is represented by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody and still achieve water quality standards and the waterbody's designated use. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be set and thereby provide the basis to establish water-quality-based controls. These TMDLs are expressed as annual mass loads, since the approach used to determine the TMDL targets relied on annual loadings. The TMDLs targets were determined to be the conditions needed to restore and maintain a balanced aquatic system. Furthermore, it is important to consider nutrient loading over time, since nutrients can accumulate in waterbodies.

As presented in Section 7 the reductions in the *Future* as well as the *Natural* condition simulations evaluated against the existing daily average DO standard were not sufficient to meet the criteria in both McKay Bay and the Palm River Tidal. As such, the TMDL defined for the loads entering these WBIDs was set to the *Natural* loading condition. Table 9 presents the Natural condition loads over the period of the simulations from 2003 through 2007 with the average for that period. The natural condition loads are presented for the portion of Ybor City Drain that flows into McKay Bay as well as for the Palm River Tidal watershed.

Table 9 – Natural Condition Loads for Palm River Tidal and Ybor City Drain Portion Which Drains to McKay Bay

Year	TN (lb/yr)	TP (lb/yr)
Palm River Tidal		
2003	78798	13919
2004	66396	12271
2005	44180	9806
2006	53549	11079
2007	48128	10281
Average	58210	11471
Ybor City Drain		
2003	10734	2239
2004	9015	1955
2005	6962	1647
2006	8411	1920
2007	7242	1684
Average	8473	1889
McKay Bay		
2003	89532	16157
2004	75411	14227
2005	51142	11454
2006	61961	12999
2007	55370	11965
Average	66683	13360

The TMDLs for the three WBIDs (Ybor City Drain, Palm River Tidal, and McKay Bay) were determined as the Natural condition loads from Ybor City Drain (which flow into McKay Bay), the loads to the Palm River Tidal, and the total load to McKay Bay, respectively. These are presented in Table 10a and 10 b. For this condition, the WLA for the point sources was set to 0.

Table 10a – TMDL Load Allocations for Total Nitrogen

WBID		WLA				
No.	Name	MS4s (lbs/year)	Point Sources (lbs/year)	LA	MOS	TMDL (lbs/year)
1584B	McKay Bay	66,683	0	N/A	Implicit	66,683
1536E	Palm River Tidal	58,210	0	N/A	Implicit	58,210
1584A	Ybor City Drain	8,473	0	N/A	Implicit	8,473

Table 10b – TMDL Load Allocations for Total Phosphorus

WBID		WLA				
No.	Name	MS4s (lb/year)	Point Sources (lb/year)	LA	MOS	TMDL (lbs/year)
1584B	McKay Bay	13,360	0	N/A	Implicit	13,360
1536E	Palm River Tidal	11,471	0	N/A	Implicit	11,471
1584A	Ybor City Drain	1,889	0	N/A	Implicit	1,889

8.1. Critical Conditions and Seasonal Variation

EPA regulations at 40 CFR 130.7(c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The critical condition is the combination of environmental factors creating the worst-case scenario of water quality conditions in the waterbody. By achieving the water quality standards at critical conditions, it is expected that water quality standards should be achieved during all other times. Seasonal variation must also be considered to ensure that water quality standards will be met during all seasons of the year and that the TMDLs account for any seasonal change in flow or pollutant discharges, and any applicable water quality criteria or designated uses (such as swimming) that are expressed on a seasonal basis.

The critical condition for nonpoint source loadings and wet weather point source loadings is typically an extended dry period followed by a rainfall runoff event. During the dry weather period, nutrients collect on the land surface, and are washed off by rainfall. The critical condition for continuous point source loading typically occurs during periods of low stream flow, when dilution is minimized. Although loading of nonpoint source pollutants contributing to a nutrient impairment may occur during a runoff event, the expression of that nutrient impairment is more likely to occur during warmer months, and at times when the waterbody is poorly flushed. The period used for the model calibration, as well as the developed period Future condition scenarios, presents a full range of hydrologic conditions from wet years to dry years, therefore, the TMDL accounts for a full range of hydrologic conditions. Because the model inputs and time steps are on time scales at or less than 1 day, seasonality is considered.

8.2. Margin of Safety

The MOS accounts for uncertainty in the relationship between a pollutant load and the resultant condition of the waterbody. There are two methods for incorporating an MOS into TMDLs (USEPA, 1991):

- Implicitly incorporate the MOS using conservative model assumptions to develop allocations
- Explicitly specify a portion of the total TMDL as the MOS and use the remainder for allocations

This TMDL uses an implicit MOS based upon using long term simulations that cover all meteorological and hydrological conditions.

8.3. Waste Load Allocations

Only MS4s and NPDES facilities discharging directly into lake segments (or upstream tributaries of those segments) are assigned a WLA. The WLAs, if applicable, are expressed separately for continuous discharge facilities (e.g., wastewater treatment plants) and MS4 areas, as the former discharges during all weather conditions and the latter discharges in response to storm events.

8.3.1. Wastewater/Industrial Permitted Facilities

The WLA loads provided in the TMDL were set to 0 based upon the use of the Natural condition loads.

8.3.2. Municipal Separate Storm Sewer System Permits

The entire watershed draining to the Palm River and McKay Bay is within the following Phase 1 permits.

- FLS000006 – Hillsborough County and FDOT District 7
- FLS000008 – City of Tampa
- FLS000009 – City of Temple Terrace

All nonpoint source loads to the system are, by definition, under the WLA for the MS4. The TMDL loads, therefore, represent the cumulative loads from the MS4 areas.

This TMDL assumes for the reasons stated that it is infeasible to calculate numeric water-quality-based effluent limitations for stormwater discharges. Therefore, in the absence of information presented to the permitting authority showing otherwise, this TMDL assumes that water-quality-based effluent limitations for stormwater sources of nutrients derived from this TMDL can be expressed in narrative form (e.g., as BMPs), provided that:

1. The permitting authority explains in the permit fact sheet the reasons it expects the chosen BMPs to achieve the aggregate reductions for these stormwater discharges; and
2. The state will perform ambient water quality monitoring for nutrients for the purpose of determining whether the BMPs, in fact, are achieving such aggregate wasteload allocation.

All Phase 1 MS4 permits issued in Florida include a re-opener clause allowing permit revisions for implementing TMDLs once they are formally adopted by rule.

8.4. Load Allocations

As all of the watershed under consideration is within the Phase I MS4 area, no load allocations are prescribed.

9. Recommendations/Implementation

This TMDL is based on mechanistic modeling of the DO and eutrophication processes using available meteorologic data, hydrologic data, stream geometry, water chemistry data, and the evidence of low reaeration, high detrital loading, strong photosynthetic activity, and strong SOD. The lack of SOD measurements, reaeration measurements, aquatic macrophyte and periphyton measurements introduces uncertainty into this TMDL. Collection of these additional data will help reduce uncertainty and better assess the contribution of potential sources, the timing of any water quality exceedances, and necessary reductions. Additionally, the implementation of load reductions as prescribed in this TMDL document is dependent upon the outcome of the proposed DO criteria revisions by FDEP.

10. References

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Florida Administrative Code. Chapter 62-303, Identification of Impaired Surface Waters.

Florida Administrative Code. Chapter 62-40, Water Resource Implementation Rule.

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